Radiological Health Data

VOLUME II, NUMBER 7

JULY 1961

Quarterly Report

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data is published by the Public Health Service on a monthly basis. Data are provided to the Division of Radiological Health by other Federal agencies, State health departments, and foreign governments. Except where material is directly quoted or otherwise credited, summaries and abstracts are prepared by the staff of the Data Collation and Analysis Unit, Division of Radiological Health. The reports are reviewed by a Board of Editorial Advisors with representatives from the following Federal agencies:

Department of Health, Education, and Welfare
Atomic Energy Commission
Department of Defense
Department of Commerce
Department of Agriculture

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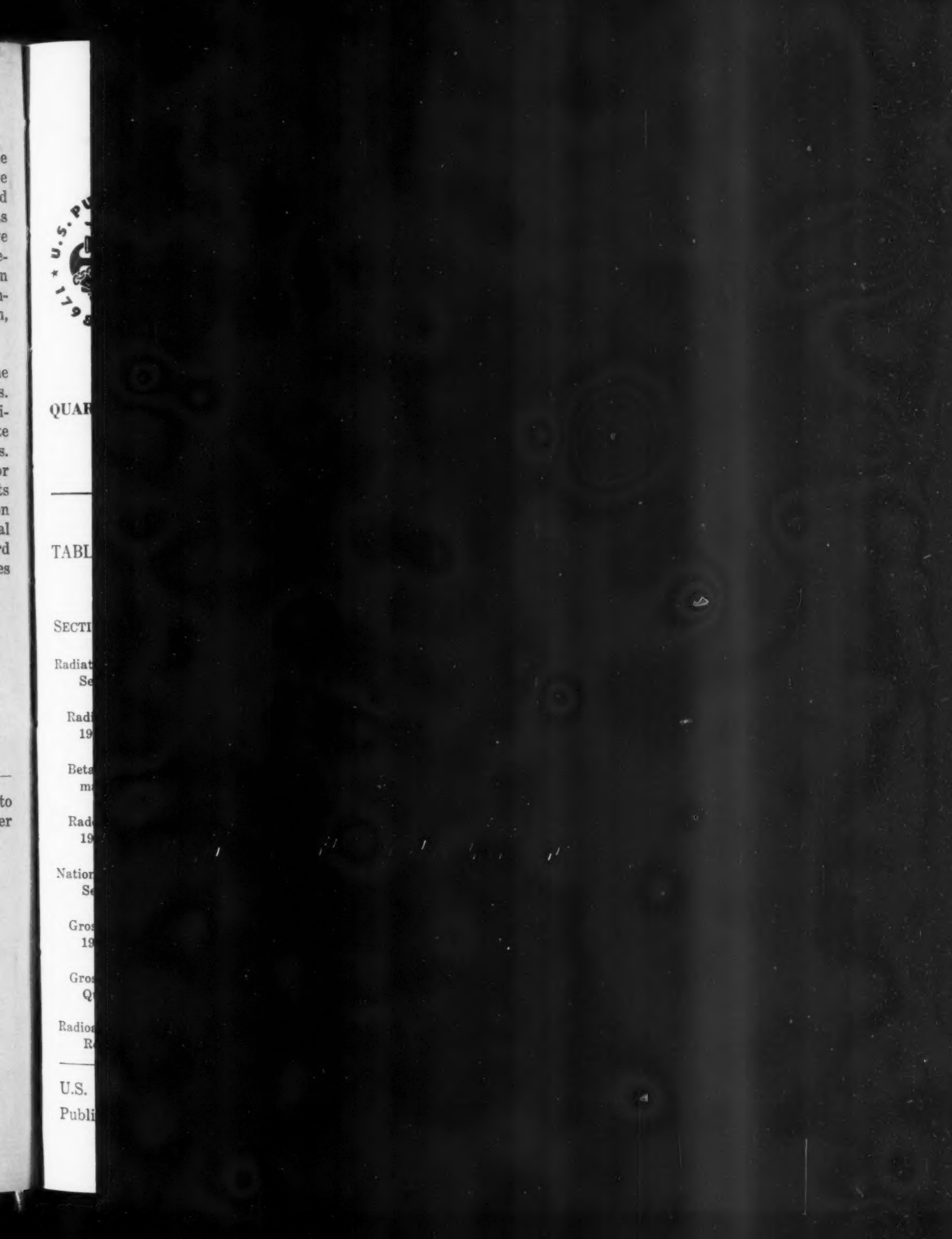

RADIOLOGICAL HEALTH DATA

QUARTERLY REPORT JULY 1961

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Public Health Service • Division of Radiological Health

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SECTION I.—AIR

Radiation Surveillance Network

Division of Radiological Health, Public Health Service

The Public Health Service Radiation Surveillance Network was established in 1956 in cooperation with the Atomic Energy Commission to provide a means of promptly determining increases in levels of environmental radioactivity due to fallout from nuclear weapons tests. Although no nuclear tests have been conducted by the United States since 1958, the program has proved sufficiently valuable that it has been extended to a year-round basis. Currently, it consists of 45 stations at urban locations (see figure 1) operated by State and local health department personnel with 2 stations operated by Public Health Service personnel.

Measurements of gross beta radioactivity in air have been taken since they provide one of the earliest and most sensitive indications of increases of activity in the environment and thus act as an "alert" system. A direct evaluation of biological hazards is not possible from these data alone. Field measurements enable the operator to estimate the amount of beta activity of particulates in air at the station five hours after collection by comparison with a known source using a portable survey meter. The filters are then forwarded to the central laboratory of the Radiation Surveillance Network in Washington, D.C., for a more refined measurement using a thin window proportional counter. The stations located at Atlanta, Georgia, and Cincinnati, Ohio, conduct their own laboratory analyses.

Air samplers are in operation at the 45 stations on an average of 70 percent of the week. Air is drawn through a carbon-loaded cellulose dust filter using a high volume air sampler. The radioactive material in fallout adhering to small particles is retained on the filter. Some gaseous fission products are adsorbed by the carbon. The contribution by gaseous fission products has represented only a small part of the total beta activity in these samples. About 85 percent of the stations collect samples of precipitation which are sent to Washington, D.C. for analysis. Values are now below limits of detection by present instrumentation.

Tables 1 and 2 summarize the data for February 1961. *Radiological Health Data*, Vol. I, No. 4 graphically presented the monthly averages of beta activity in air from about 1956 through 1959. Figures 2 through 45 bring this presentation up-to-date through 1960. It is to be noted that the levels of fission product gross beta activity in air in the United States have generally decreased below the Network's lower limit of detectability.

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

TABLE 1.—RADIOACTIVITY OF PARTICULATES IN AIR—GROSS BETA DETERMINATIONS

FEBRUARY 1961, Radiation surveillance Network, Public Health dervice

Station location	Number of samples	Maximum ($\mu\mu c/m^3$)	Minimum ($\mu\mu c/m^3$)	Weighted average ($\mu\mu c/m^3$)	Station location	Number of samples	Minimum ($\mu\mu c/m^3$)	Maximum ($\mu\mu c/m^3$)	Weighted average ($\mu\mu c/m^3$)
Anchorage, Alaska	19	0.11	<0.10	<0.10	Pascagoula, Miss	18	0.26	<0.10	<0.13
Fairbanks, Alaska	20	0.12	<0.10	<0.10	Jefferson City, Mo	17	<0.10	<0.10	<0.10
Juneau, Alaska	20	<0.10	<0.10	<0.10	Helena, Mont	17	0.12	<0.10	<0.10
Phoenix, Ariz	3	0.20	<0.10	<0.13	Trenton, N. J	0			
Little Rock, Ark	19	0.13	<0.10	<0.11	Sante Fe, N. M	16	0.18	<0.10	<0.12
Berkeley, Calif	18	<0.10	<0.10	<0.10	Albany, N. Y	28	<0.10	<0.10	<0.10
Los Angeles, Calif	17	0.25	<0.10	<0.13	Gastonia, N. C	19	0.16	<0.10	<0.11
Denver, Colo	18	0.15	<0.10	<0.11	Oklahoma City, Okla	18	0.15	<0.10	<0.10
Hartford, Conn	27	<0.10	<0.10	<0.10	Ponca City, Okla	26	0.70	<0.10	<0.12
District of Columbia	18	0.12	<0.10	<0.10	Portland, Ore	19	<0.10	<0.10	<0.10
Jacksonville, Fla	20	0.21	<0.10	<0.12	Harrisburg, Penn	18	<0.10	<0.10	<0.10
Atlanta, Ga	15	0.12	<0.10	<0.10	Providence, R. I	18	0.13	<0.10	<0.10
Honolulu, Hawaii	19	<0.10	<0.10	<0.10	Columbia, S. C	4	0.11	<0.10	<0.11
Boise, Idaho	8	0.12	<0.10	<0.10	Edgemont, S. Dak	[1]	[1]	[1]	[1]
Springfield, Ill	8	<0.10	<0.10	<0.10	Pierre, S. Dak	7	<0.10	<0.10	<0.10
Indianapolis, Ind	27	0.13	<0.10	<0.10	Austin, Tex	19	0.11	<0.10	<0.10
Iowa City, Iowa	20	0.22	<0.10	<0.10	El Paso, Tex	19	0.28	<0.10	<0.18
Topeka, Kan	20	0.14	<0.10	<0.10	Salt Lake City, Utah	28	0.15	<0.10	<0.10
New Orleans, La	4	0.13	<0.10	<0.11	Richmond, Va	19	0.12	<0.10	<0.10
Baltimore, Md	18	0.13	<0.10	<0.10	Seattle, Wash	15	<0.10	<0.10	<0.10
Lawrence, Mass	18	0.13	<0.10	<0.10	Madison, Wis	20	0.11	<0.10	<0.10
Lansing, Mich	28	0.10	<0.10	<0.10	Cheyenne, Wyo	8	<0.10	<0.10	<0.10
Minneapolis, Minn	8	<0.10	<0.10	<0.10					

[1] Inactivated

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Anchorage, Alaska

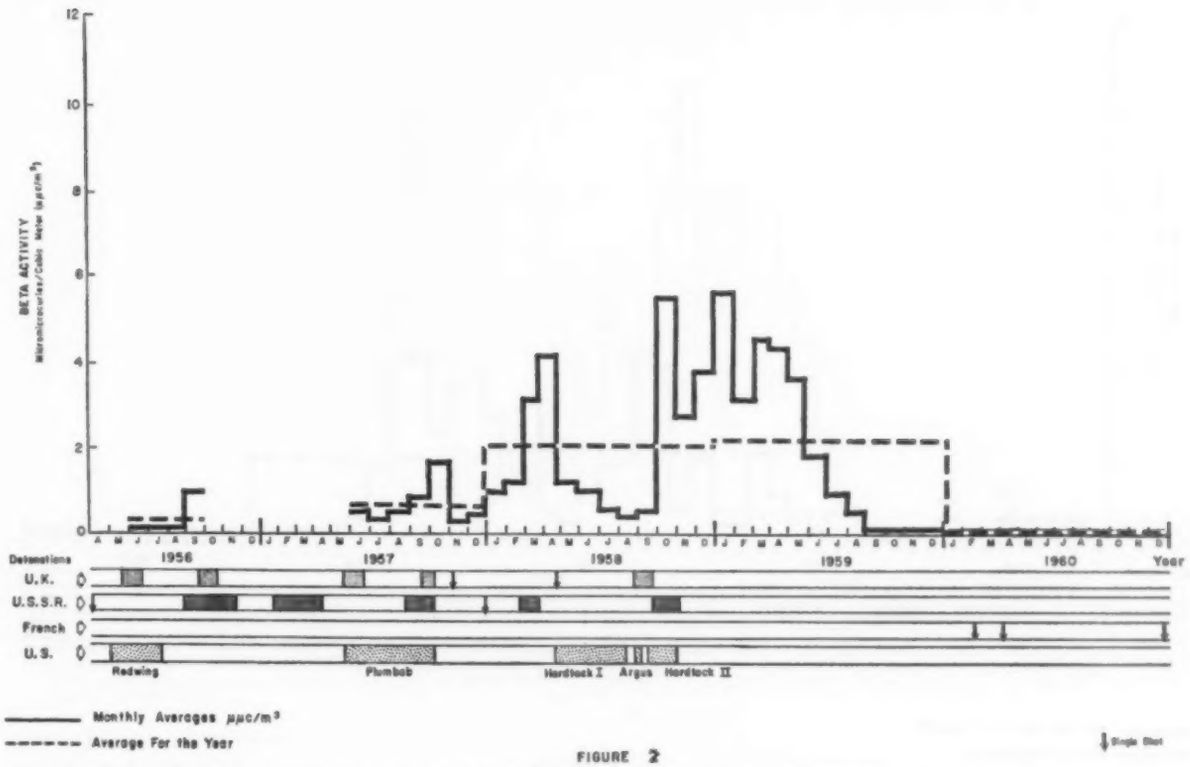


FIGURE 2

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Fairbanks, Alaska

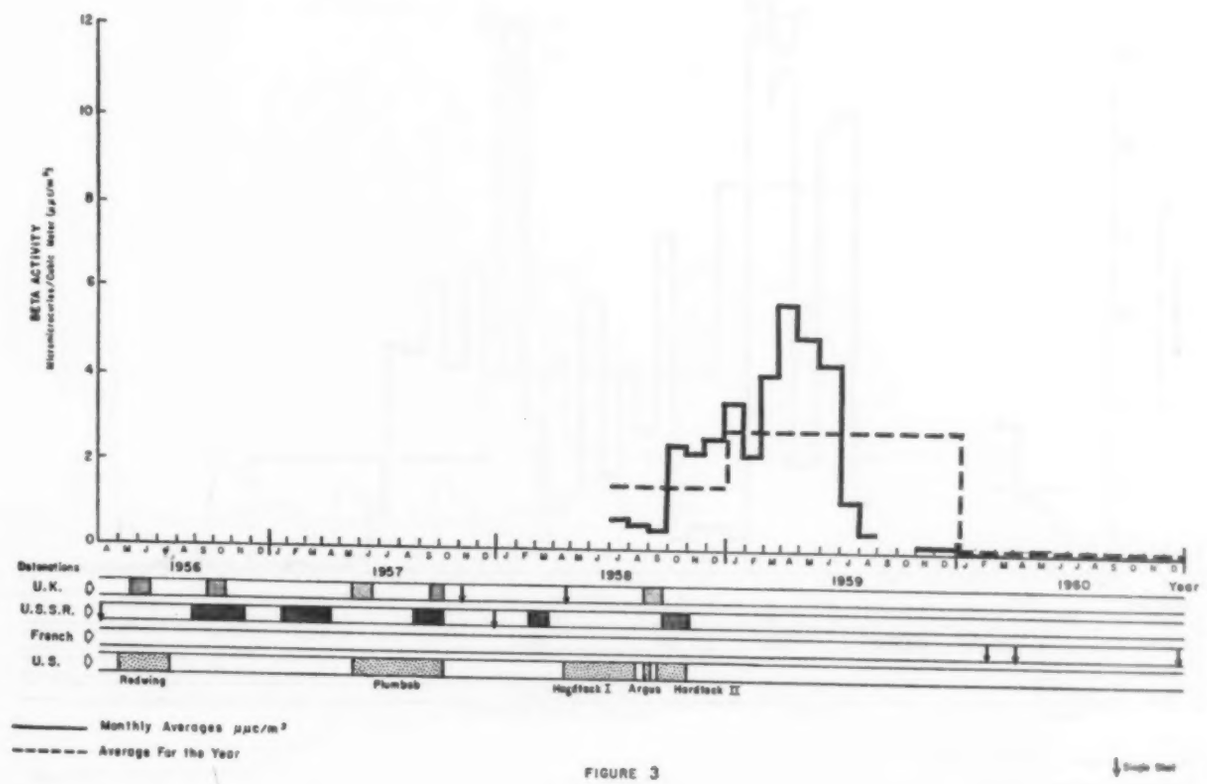


FIGURE 3

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Juneau, Alaska

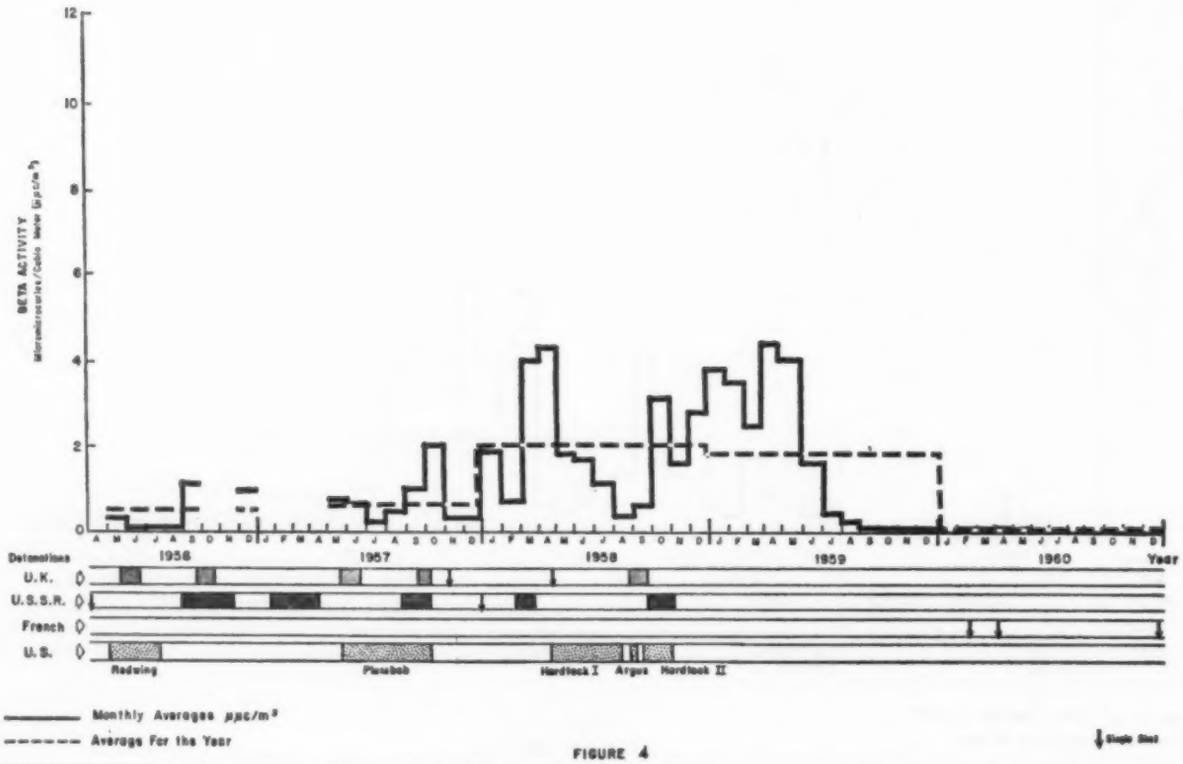


FIGURE 4

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Phoenix, Arizona

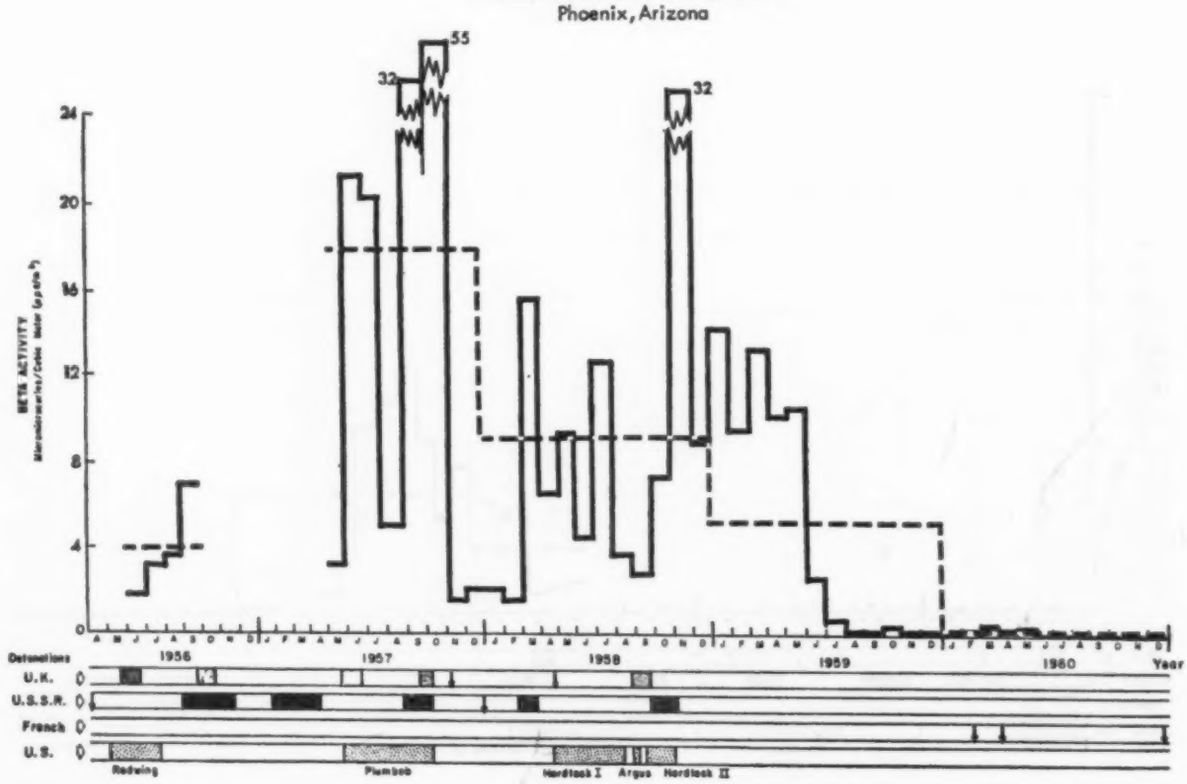


FIGURE 5

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Little Rock, Arkansas

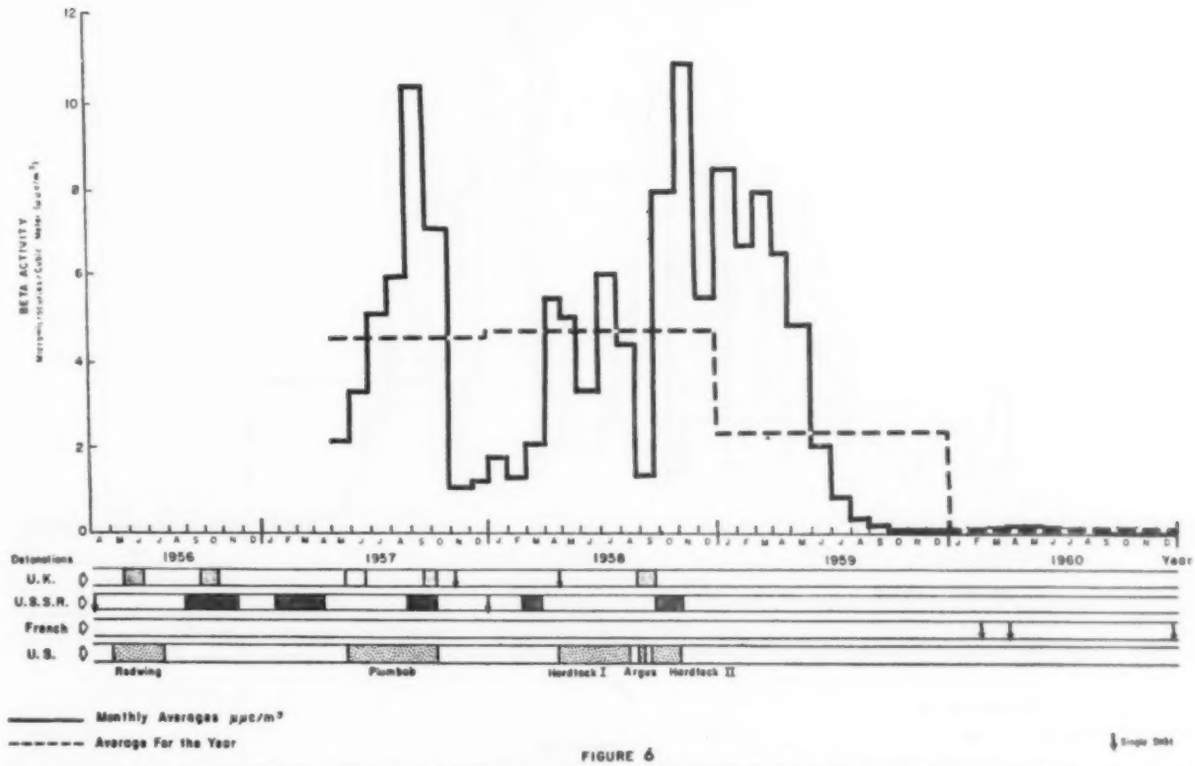


FIGURE 6

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Berkeley, California

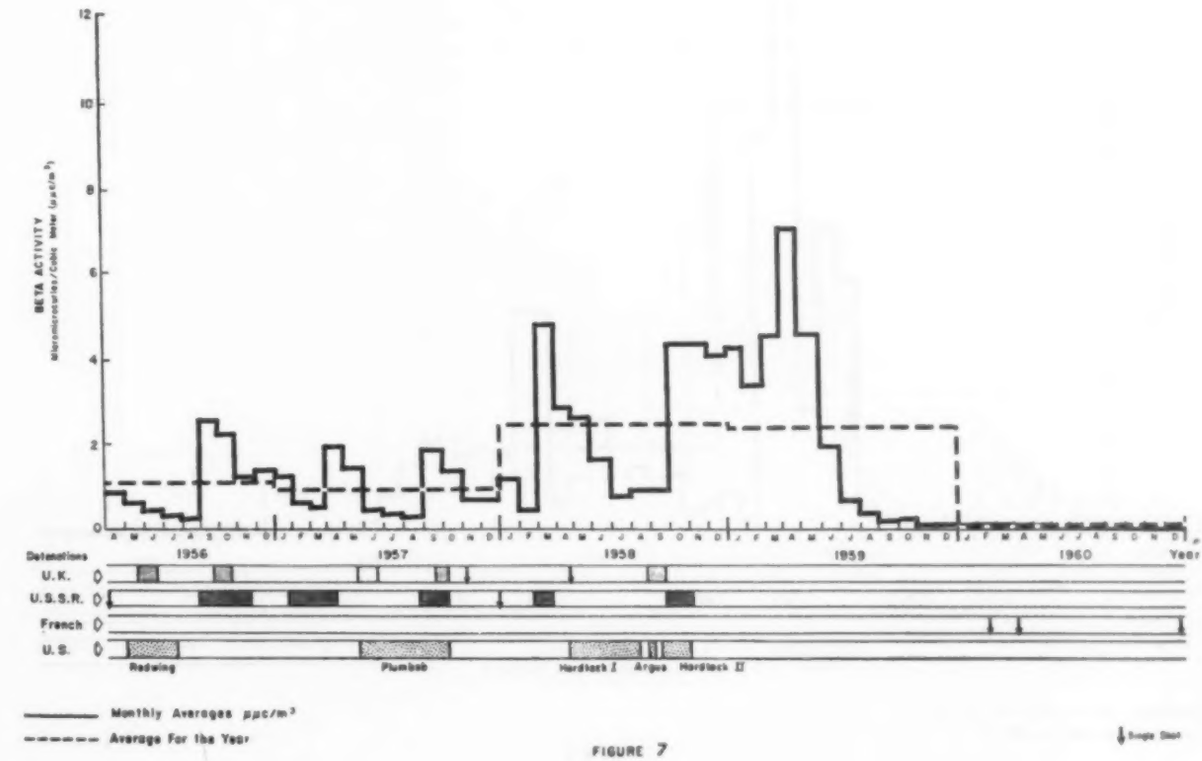
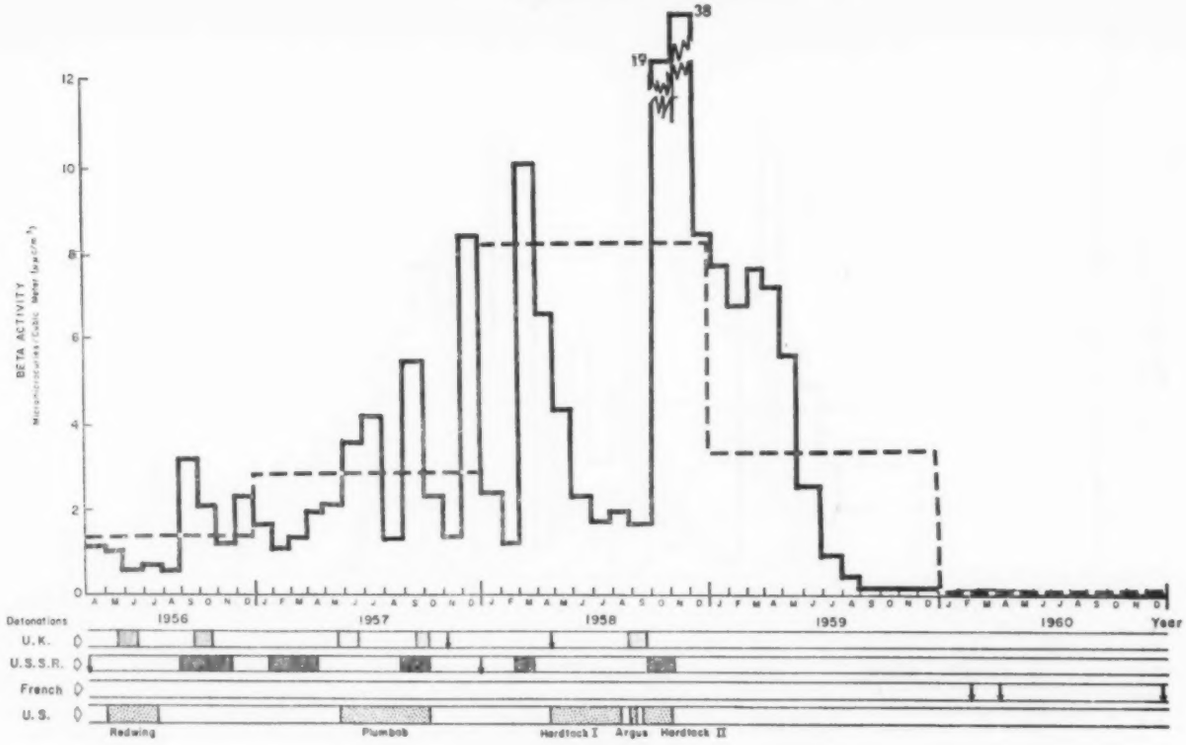


FIGURE 7

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Los Angeles, California



Monthly Averages $\mu\mu c/m^3$

Average For the Year

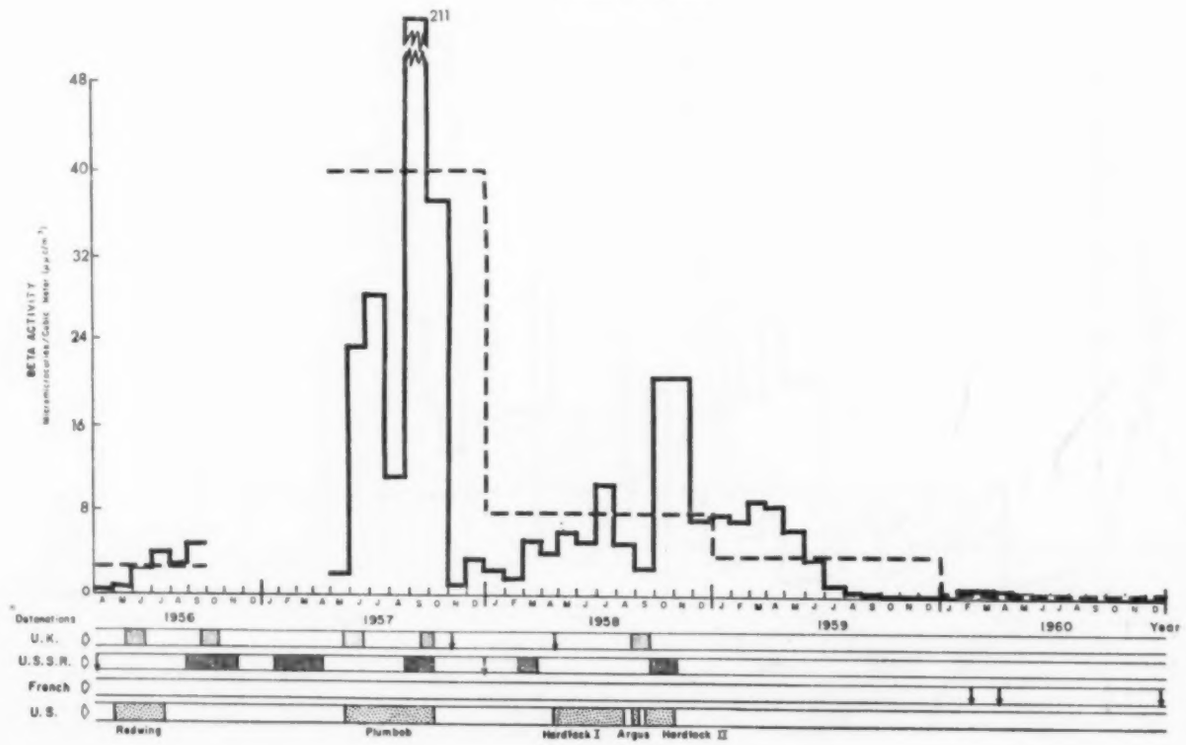
Single Shot

FIGURE 8

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Denver, Colorado



Monthly Averages $\mu\mu c/m^3$

Average For the Year

Single Shot

FIGURE 9

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Hartford, Connecticut

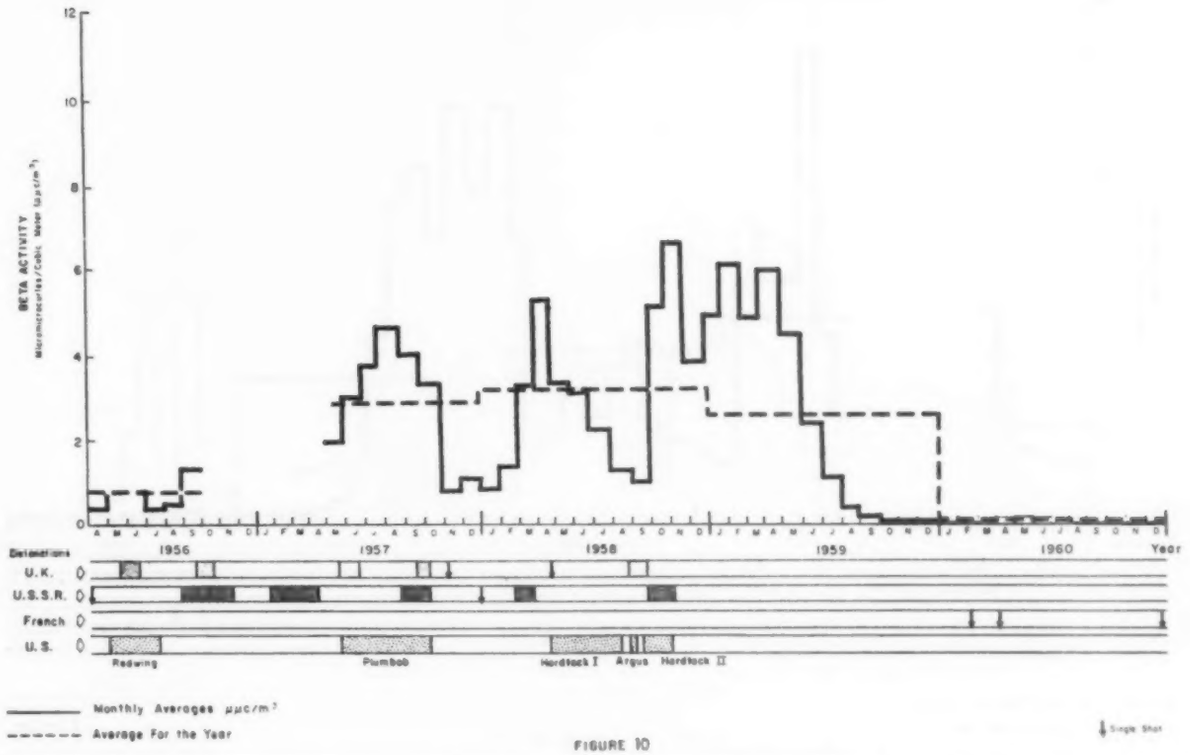


FIGURE 10

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

District of Columbia

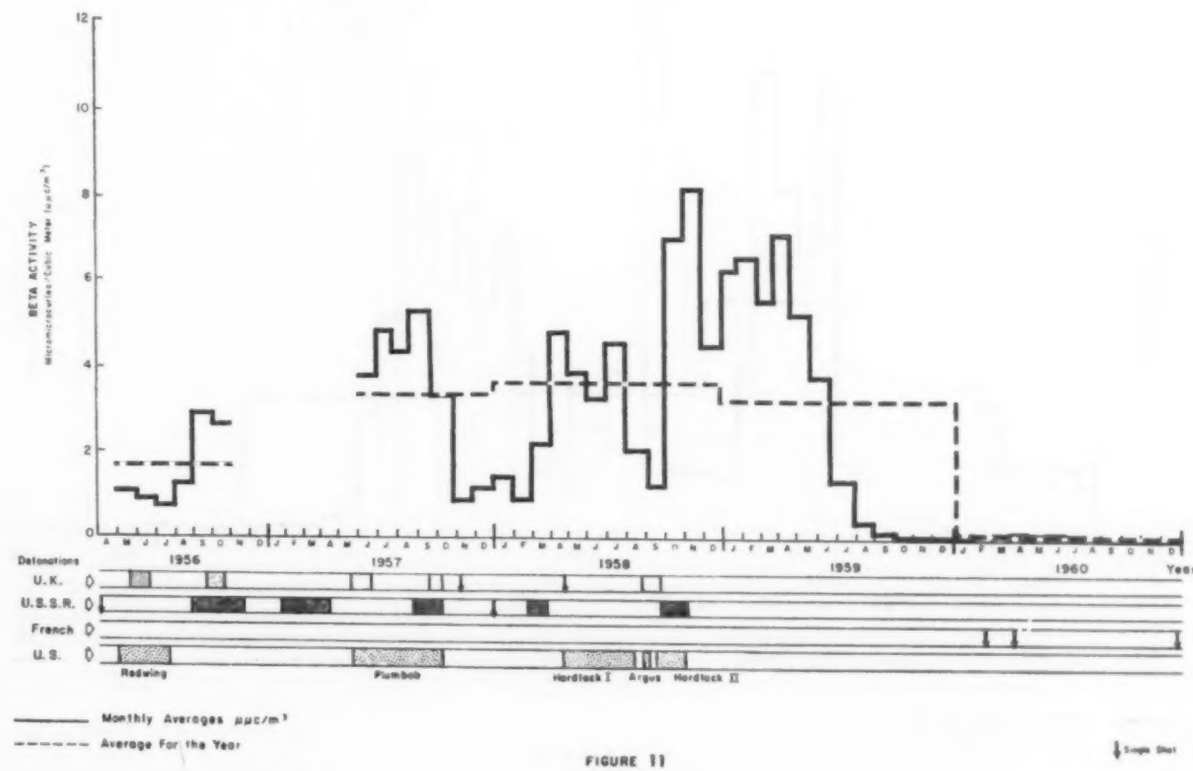


FIGURE 11

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Jacksonville, Florida

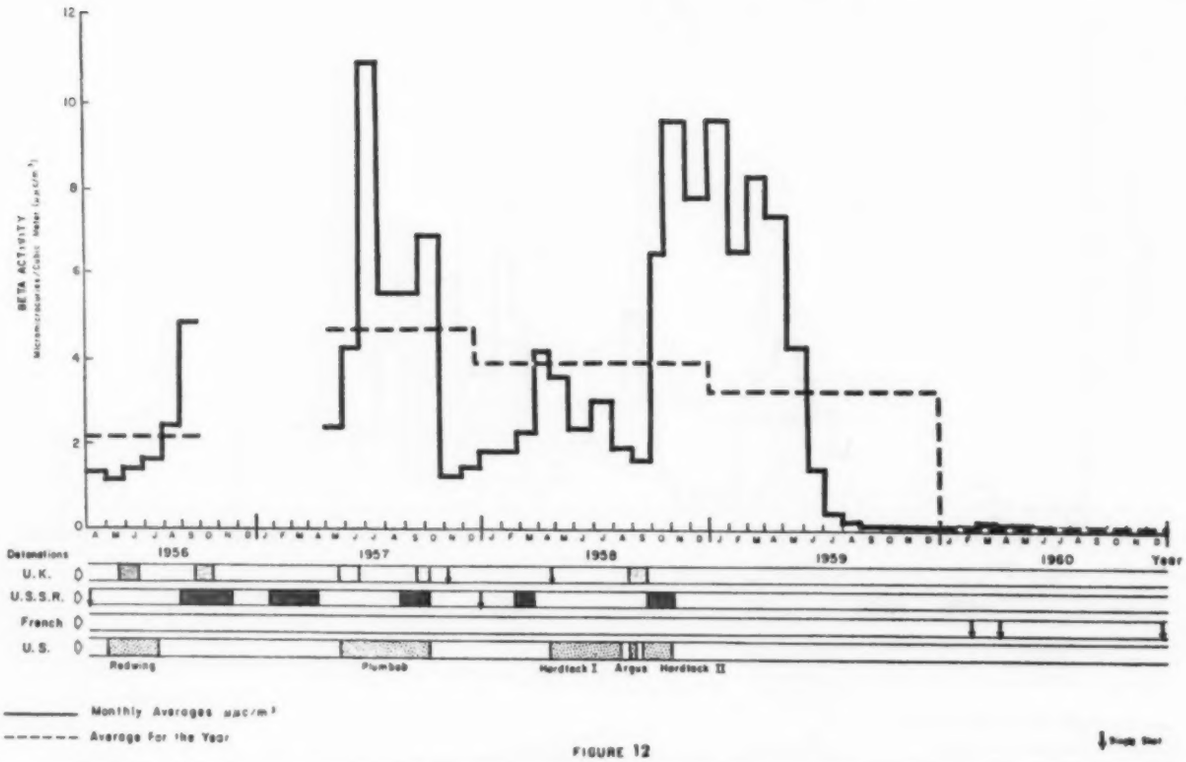


FIGURE 12

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Atlanta, Georgia

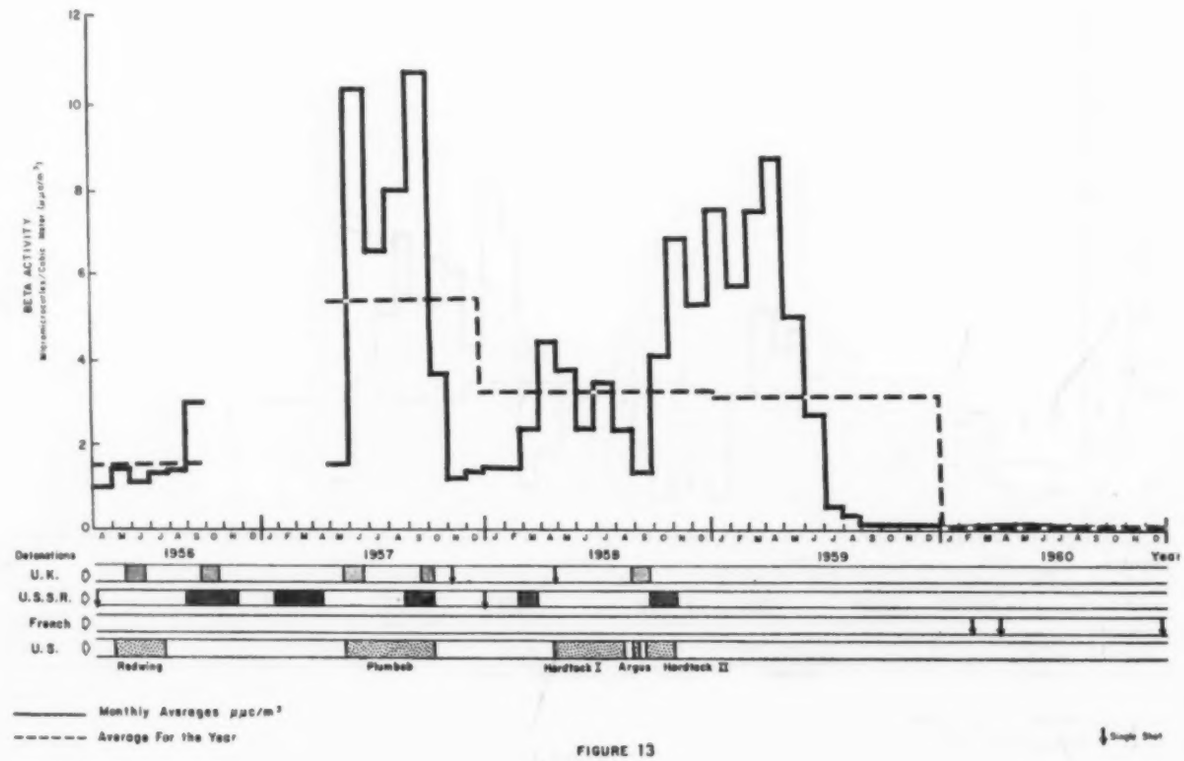


FIGURE 13

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Honolulu, Hawaii

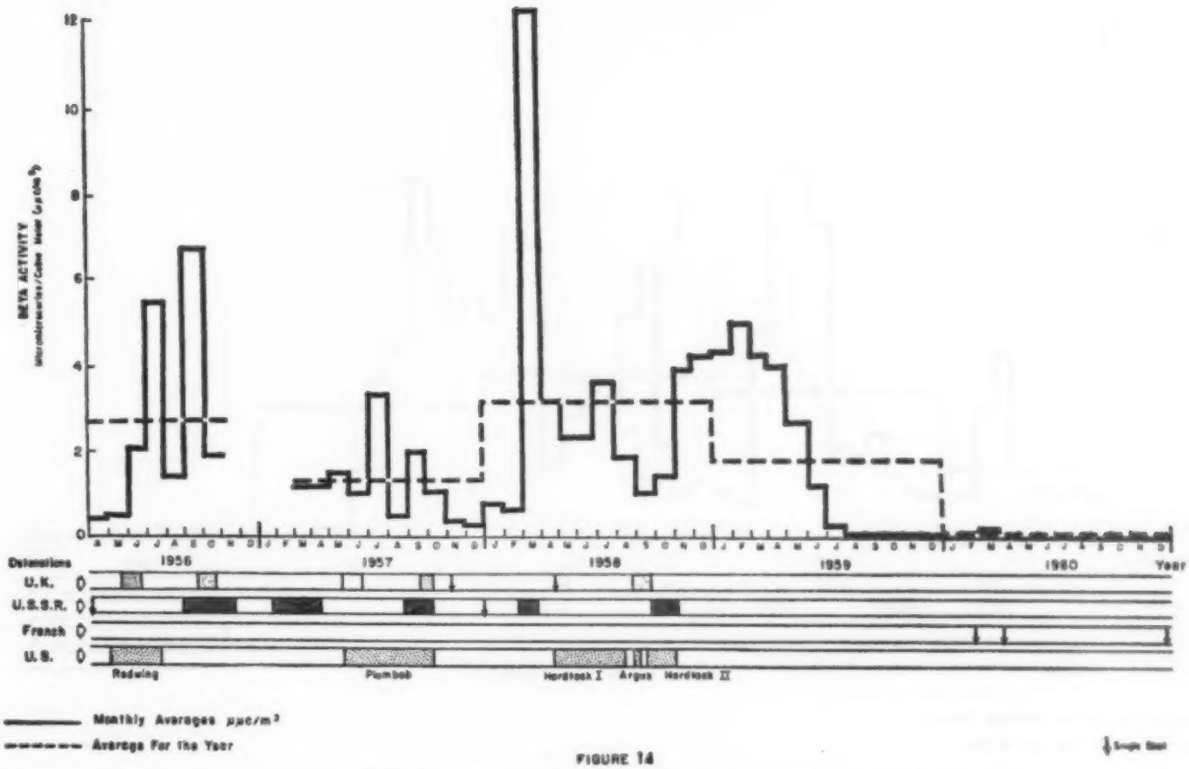


FIGURE 14

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Boise, Idaho

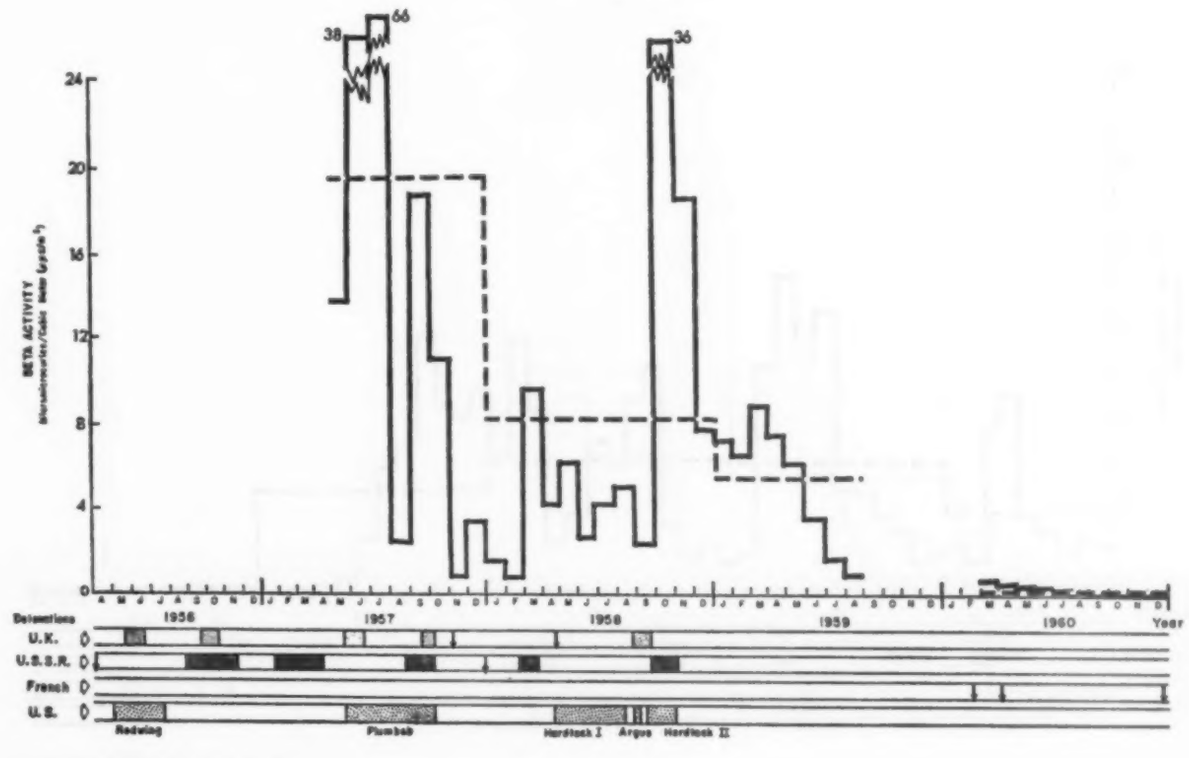


FIGURE 15

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Springfield, Illinois

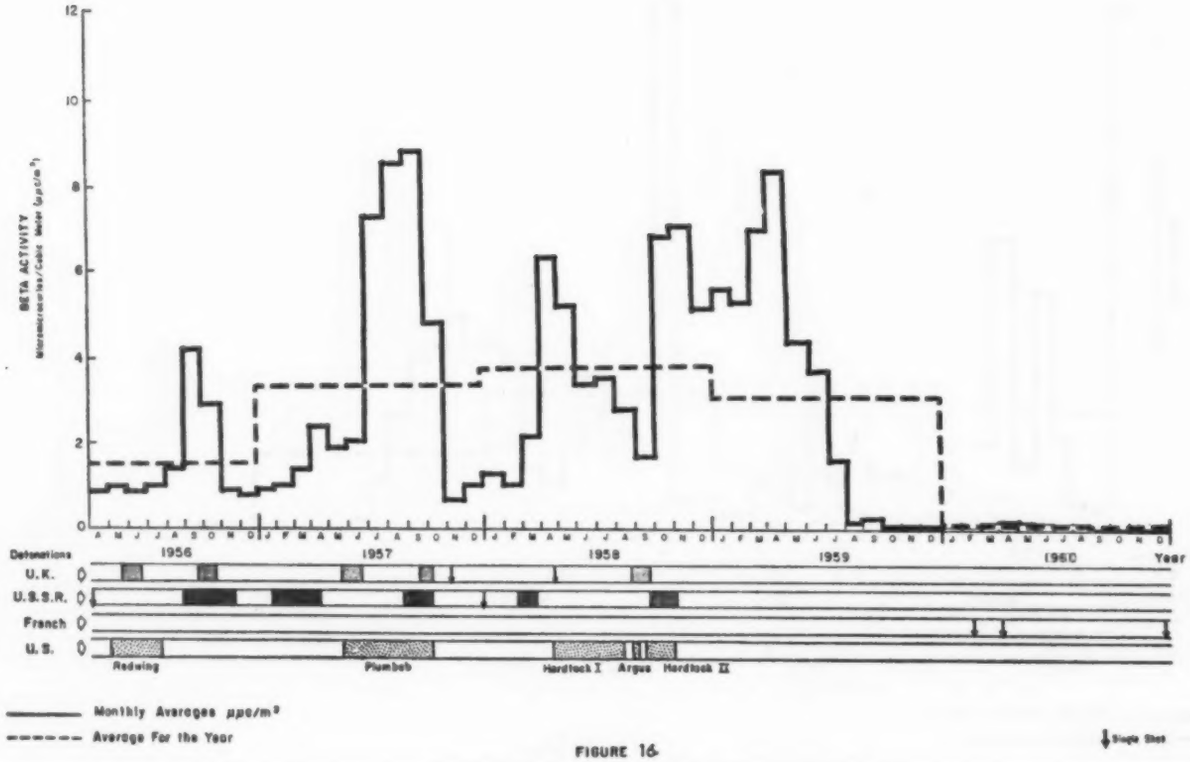


FIGURE 16

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Indianapolis, Indiana

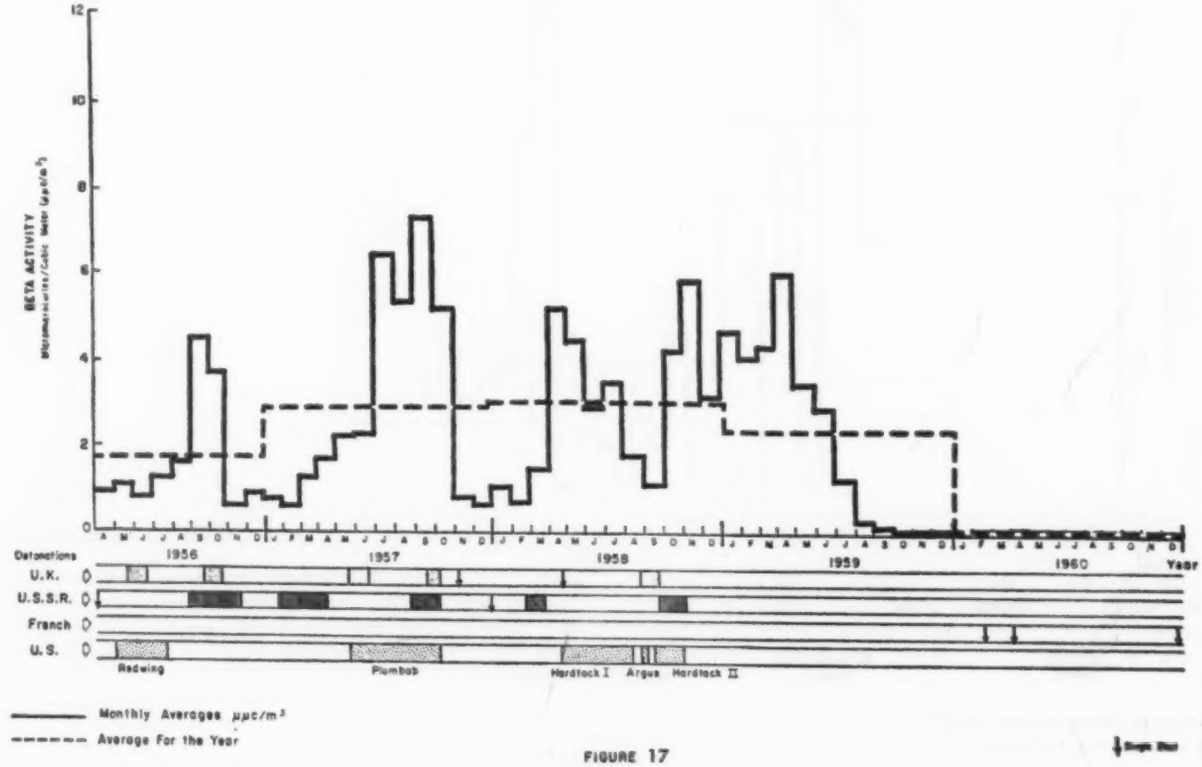


FIGURE 17

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Iowa City, Iowa

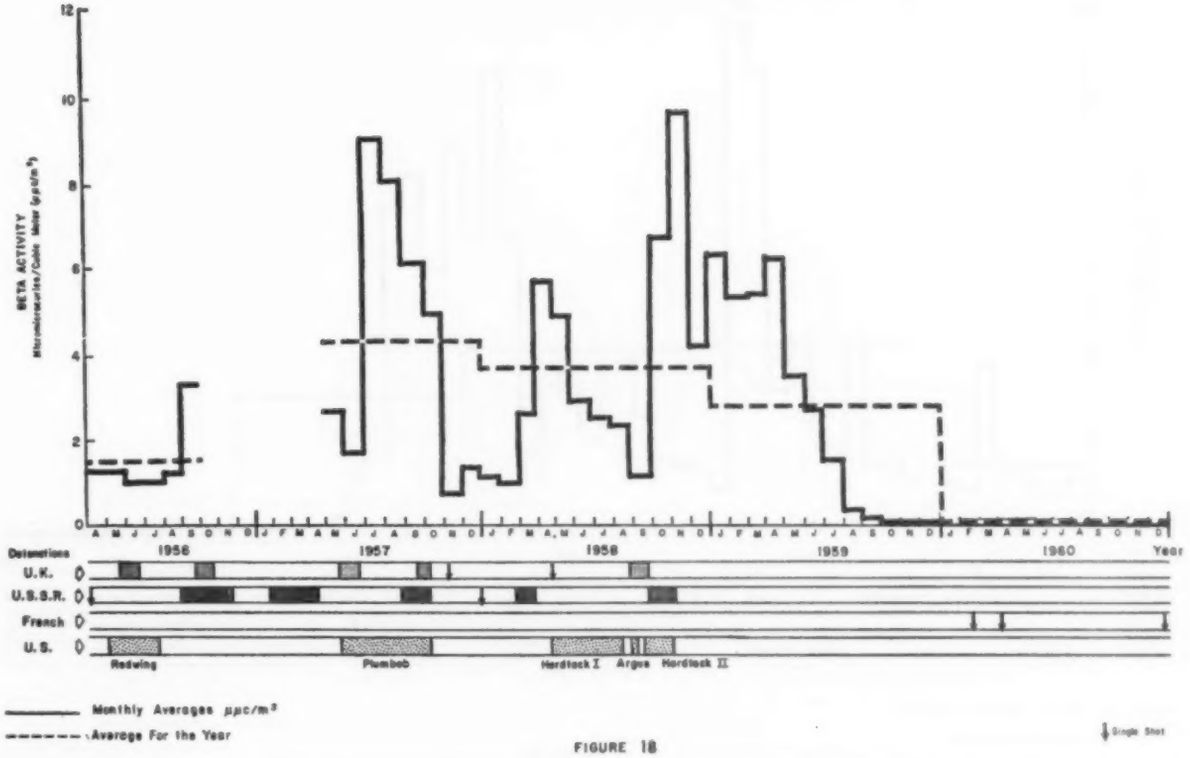


FIGURE 18

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Topeka, Kansas

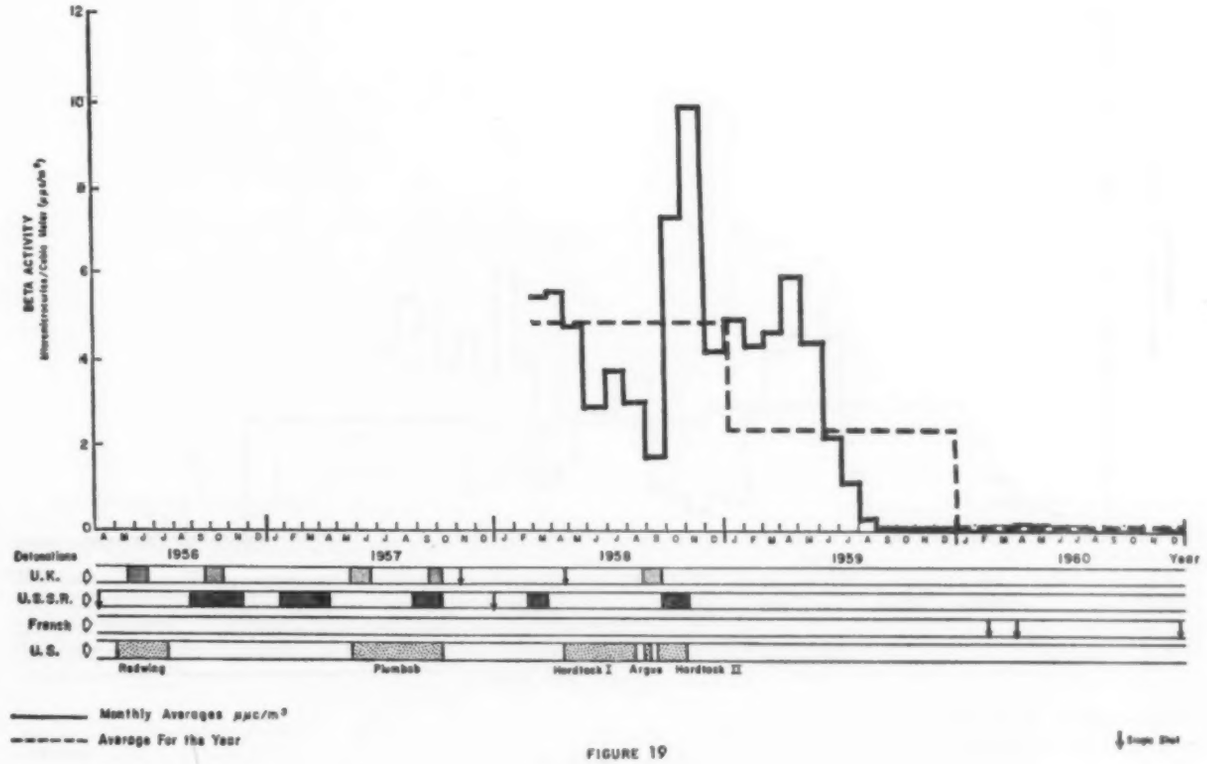


FIGURE 19

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

New Orleans, Louisiana

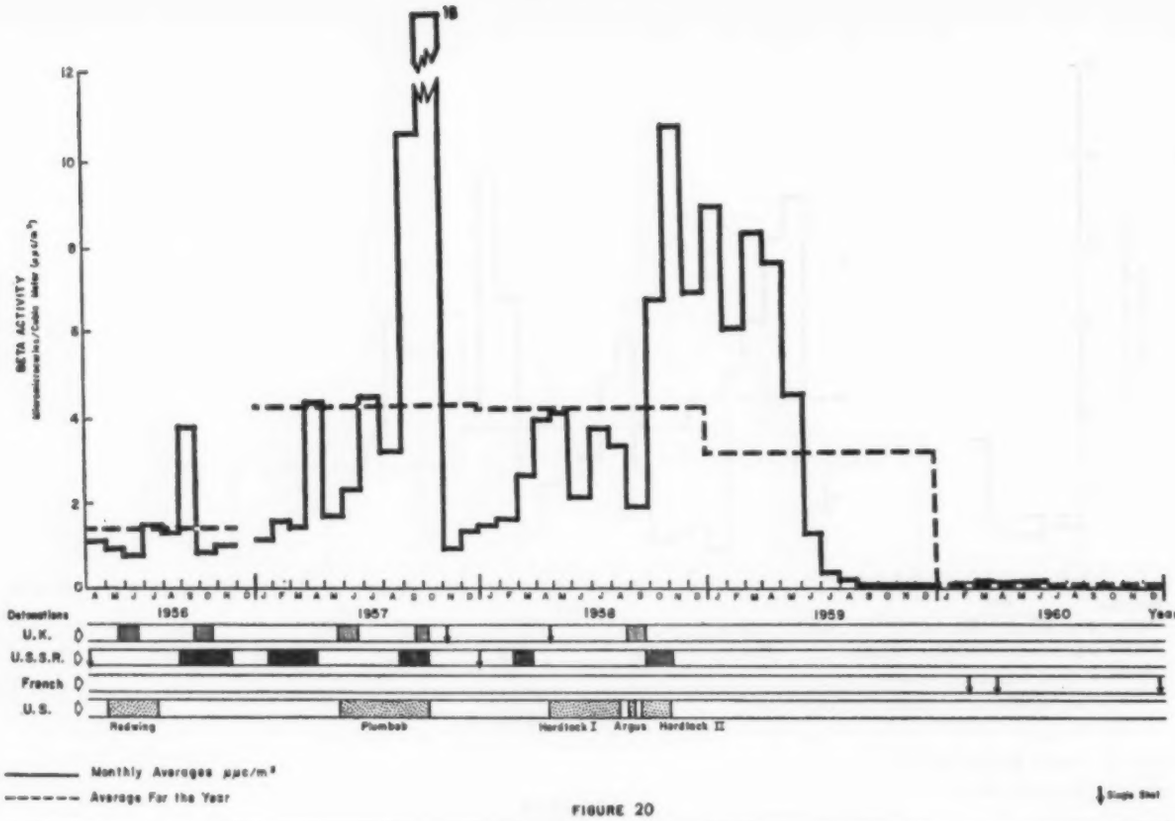


FIGURE 20

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Baltimore, Maryland

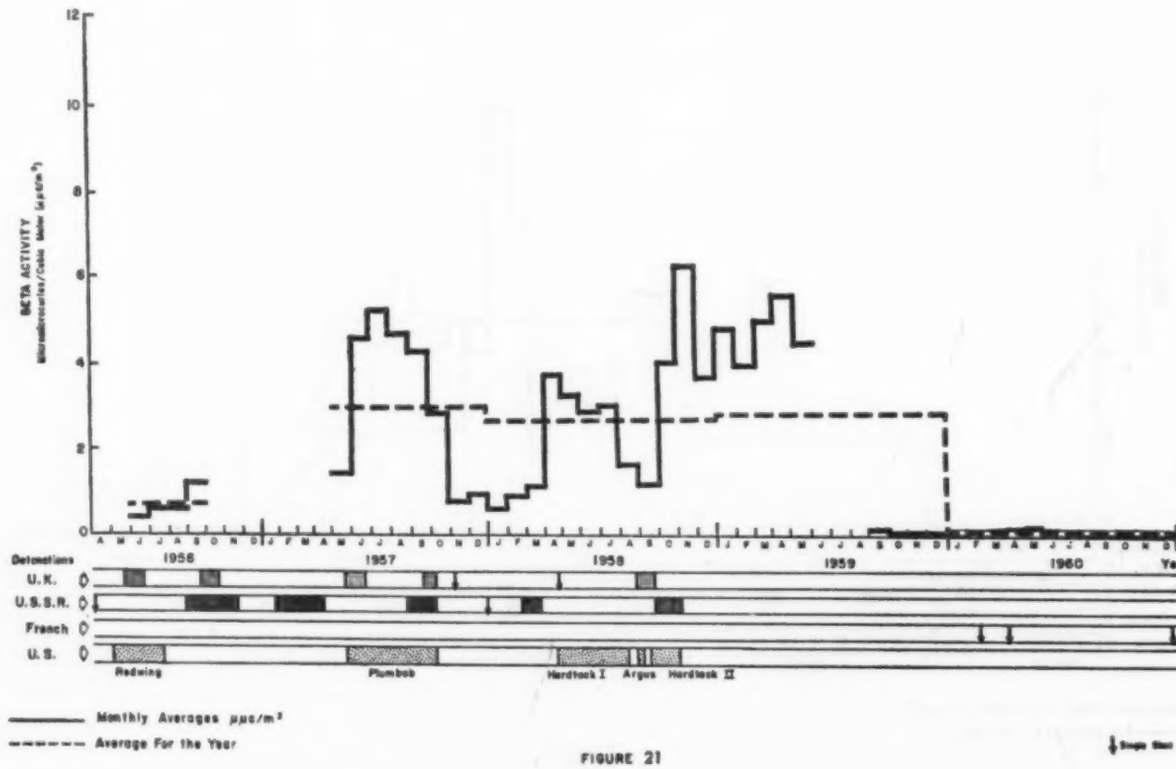


FIGURE 21

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Lawrence, Massachusetts

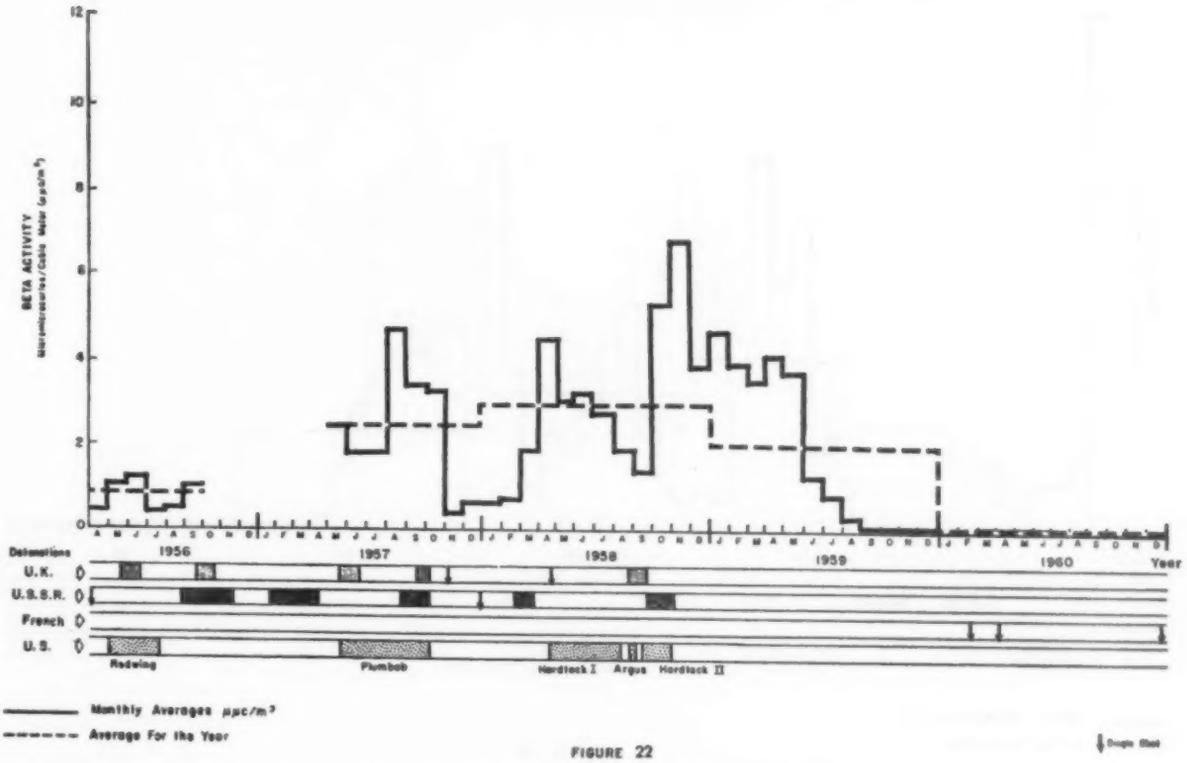


FIGURE 22

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Lansing, Michigan

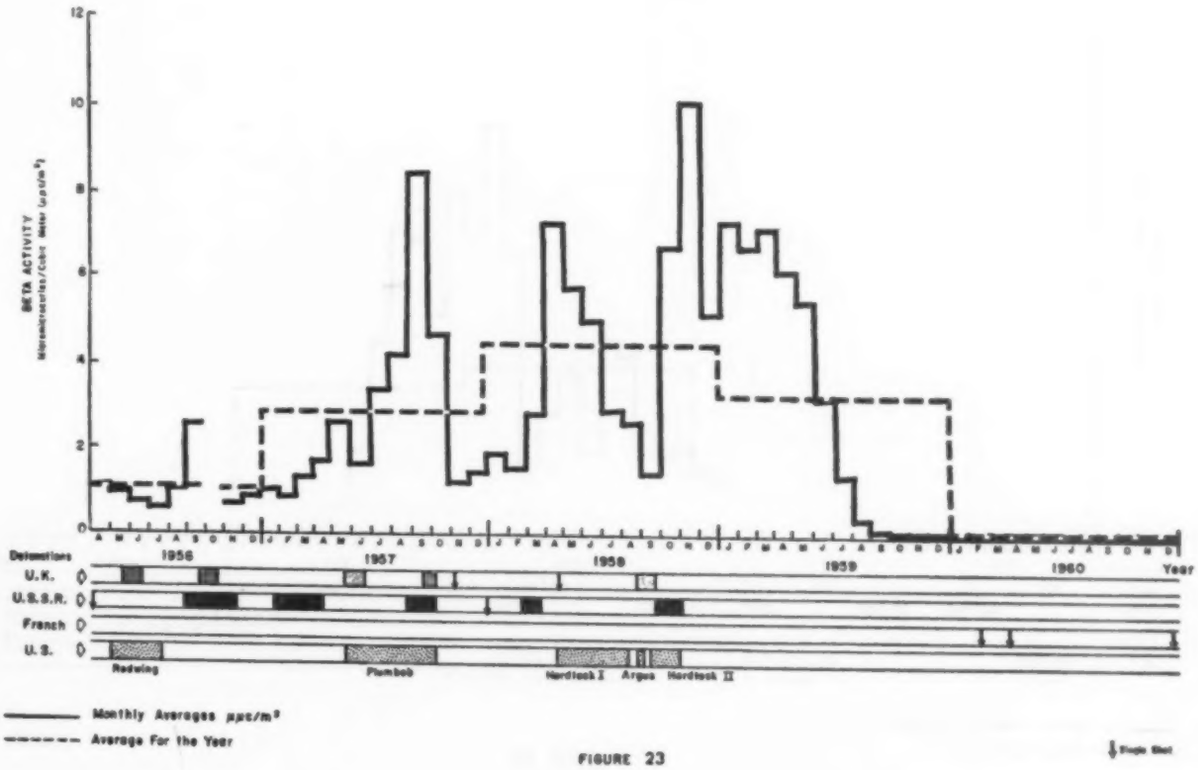


FIGURE 23

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Minneapolis, Minnesota

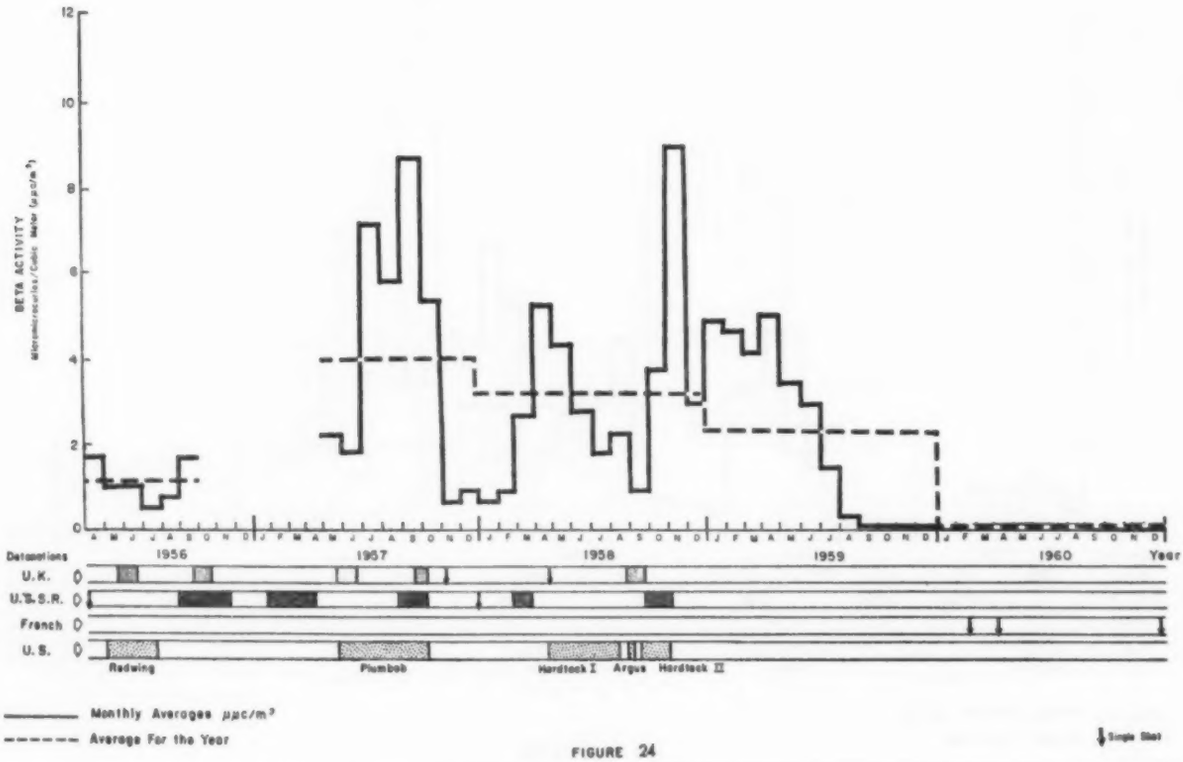


FIGURE 24

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Pascagoula, Mississippi

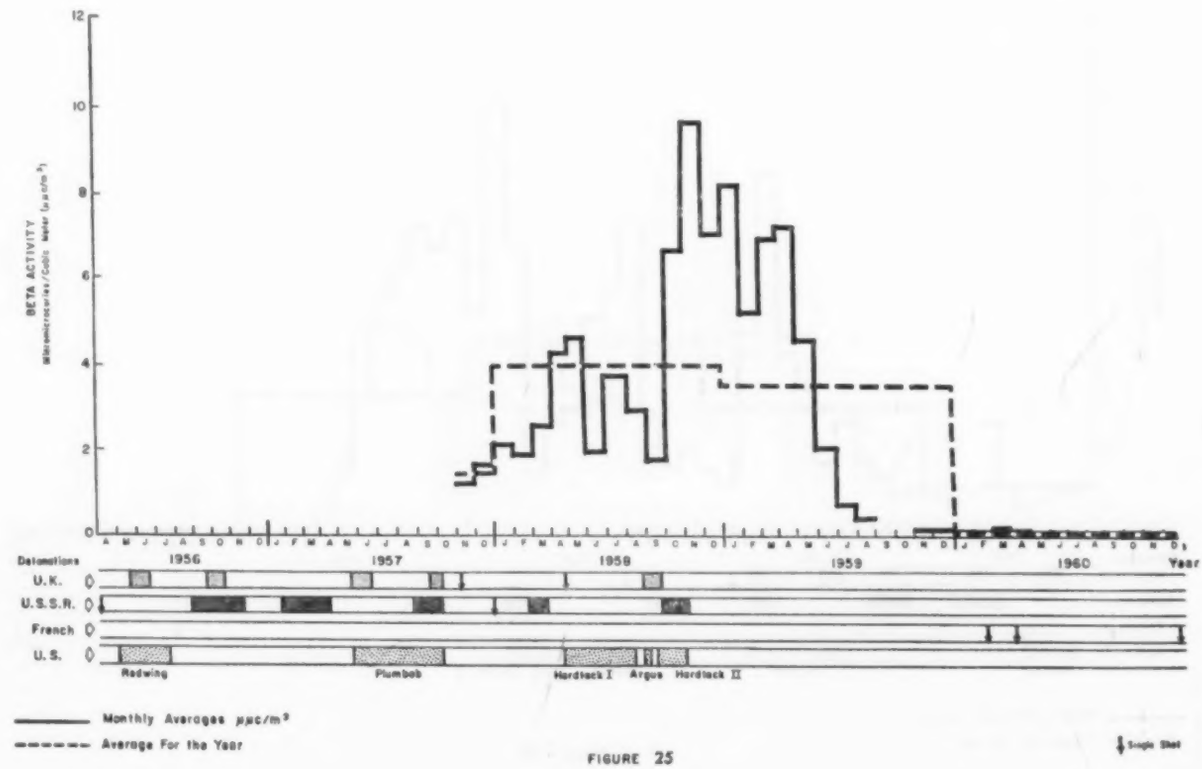


FIGURE 25

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Jefferson City, Missouri

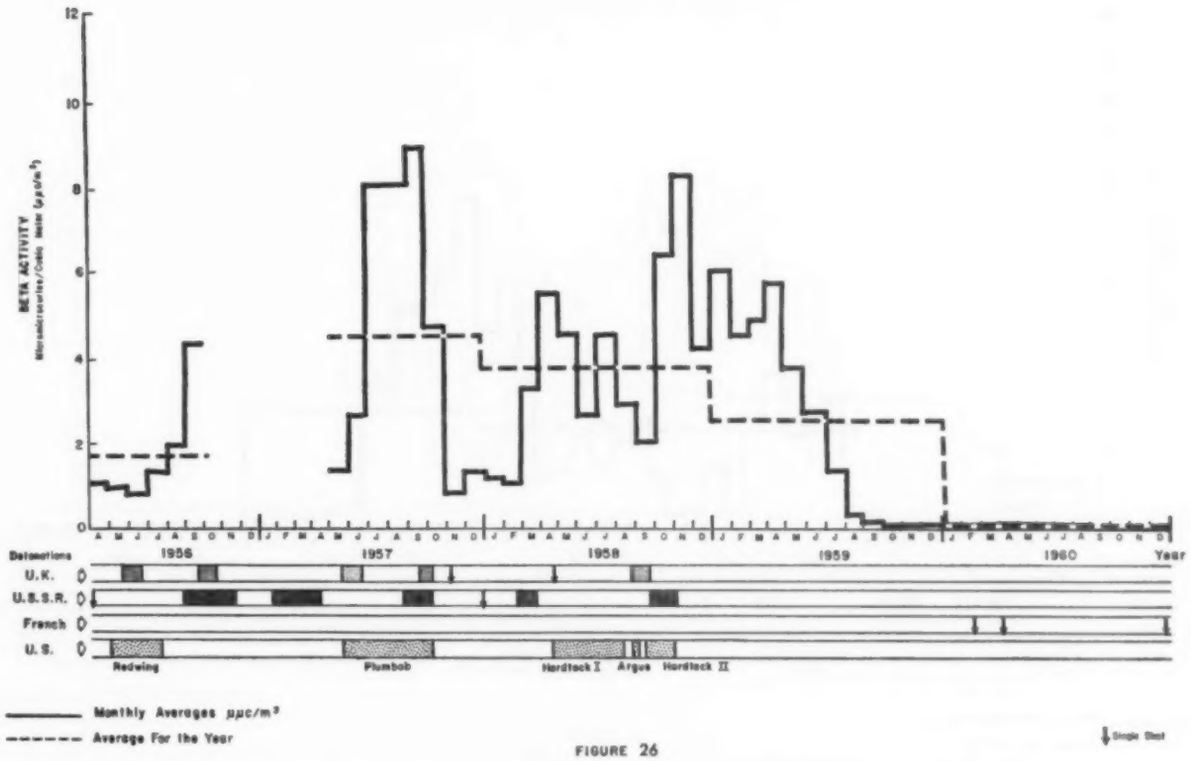


FIGURE 26

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Helena, Montana

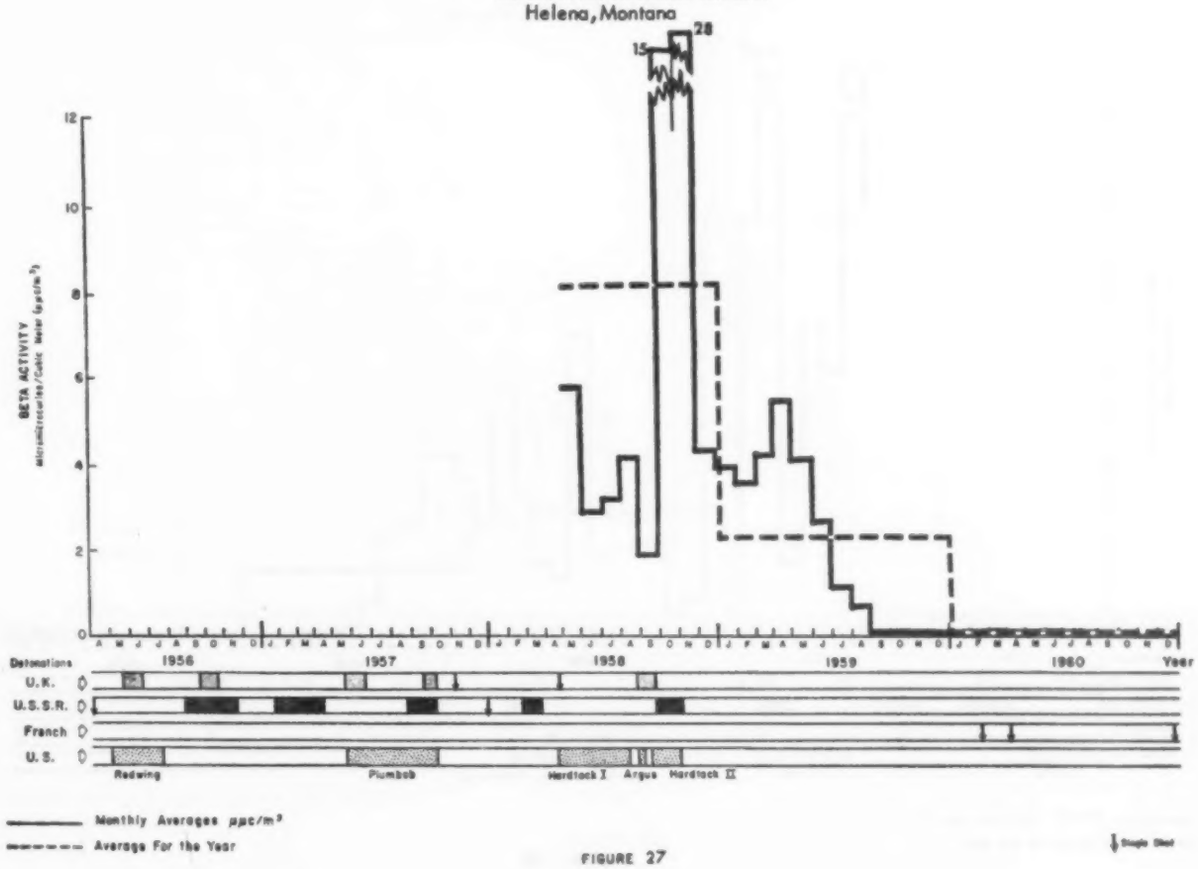


FIGURE 27

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Trenton, New Jersey

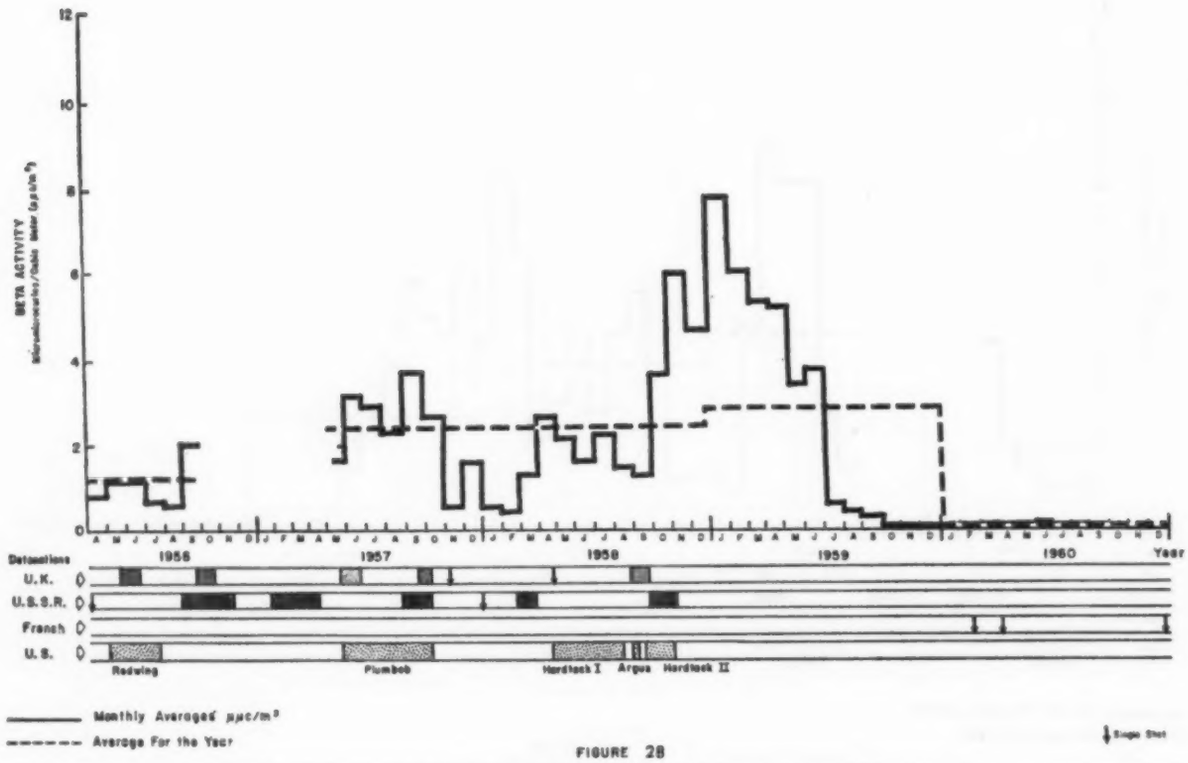


FIGURE 28

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Santa Fe, New Mexico

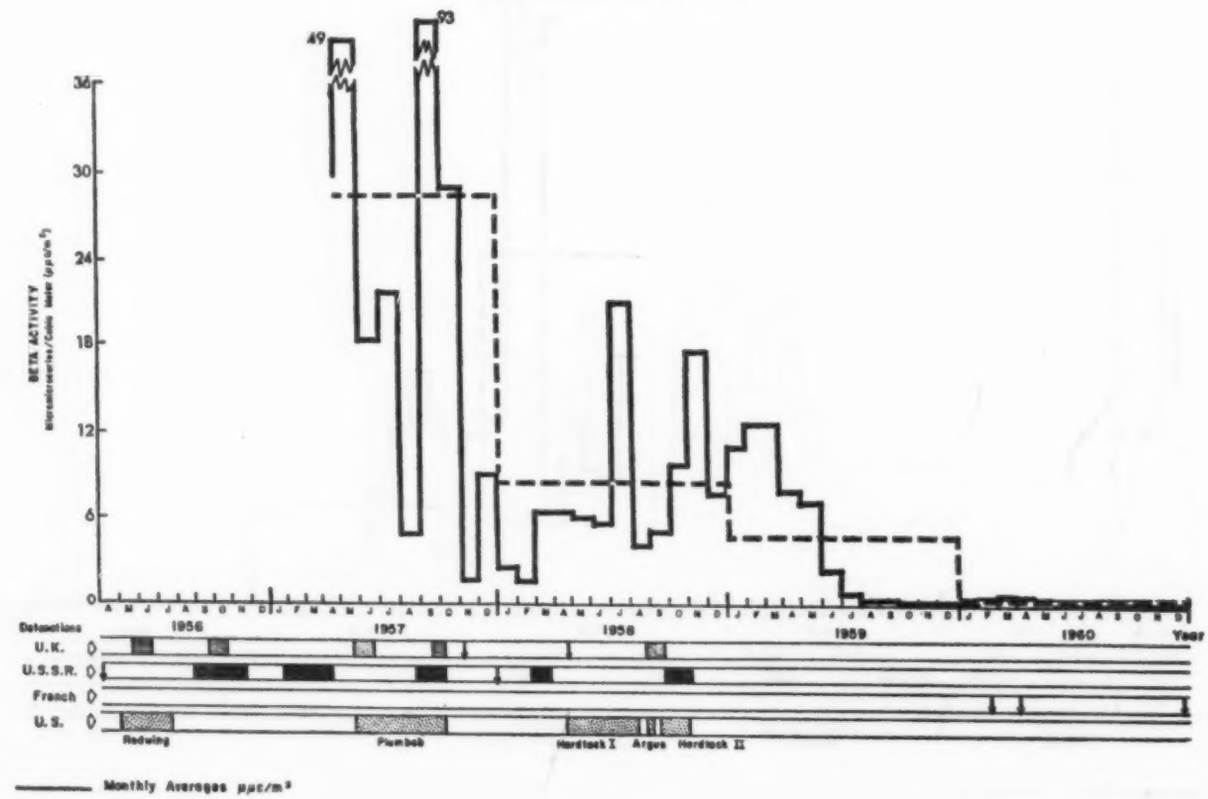


FIGURE 29

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Albany, New York

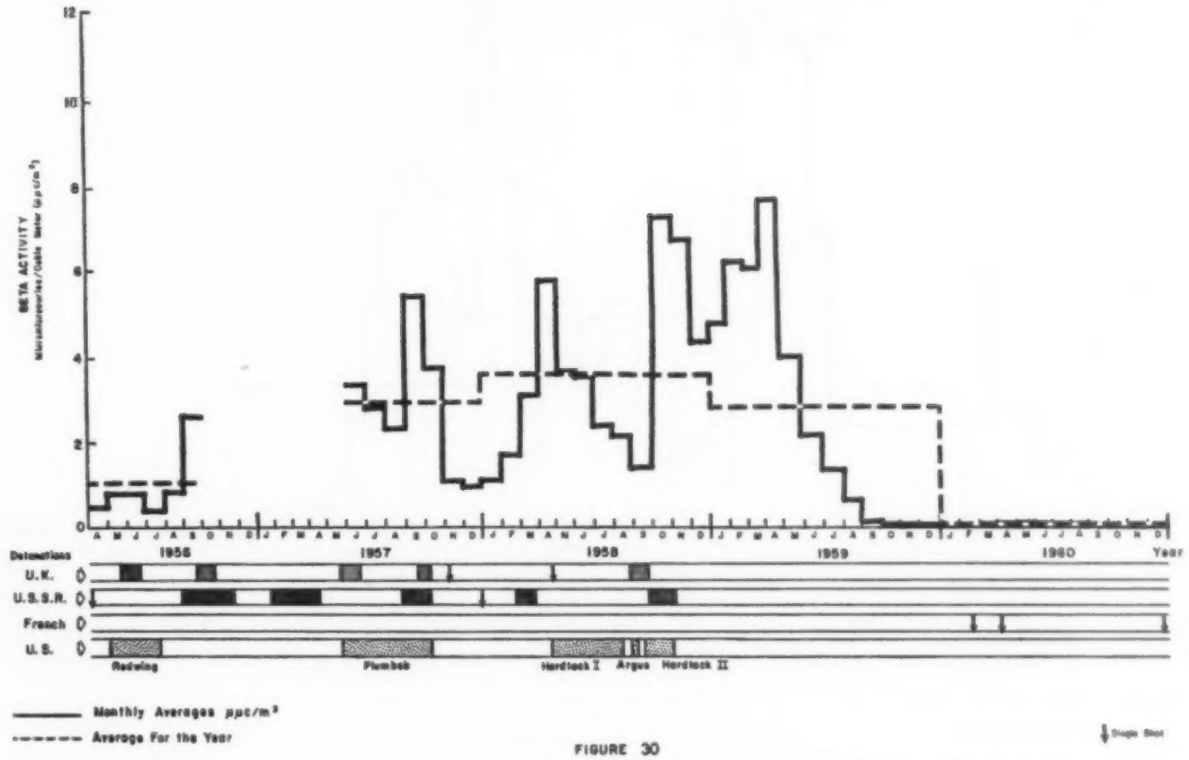


FIGURE 30

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Gastonia, North Carolina

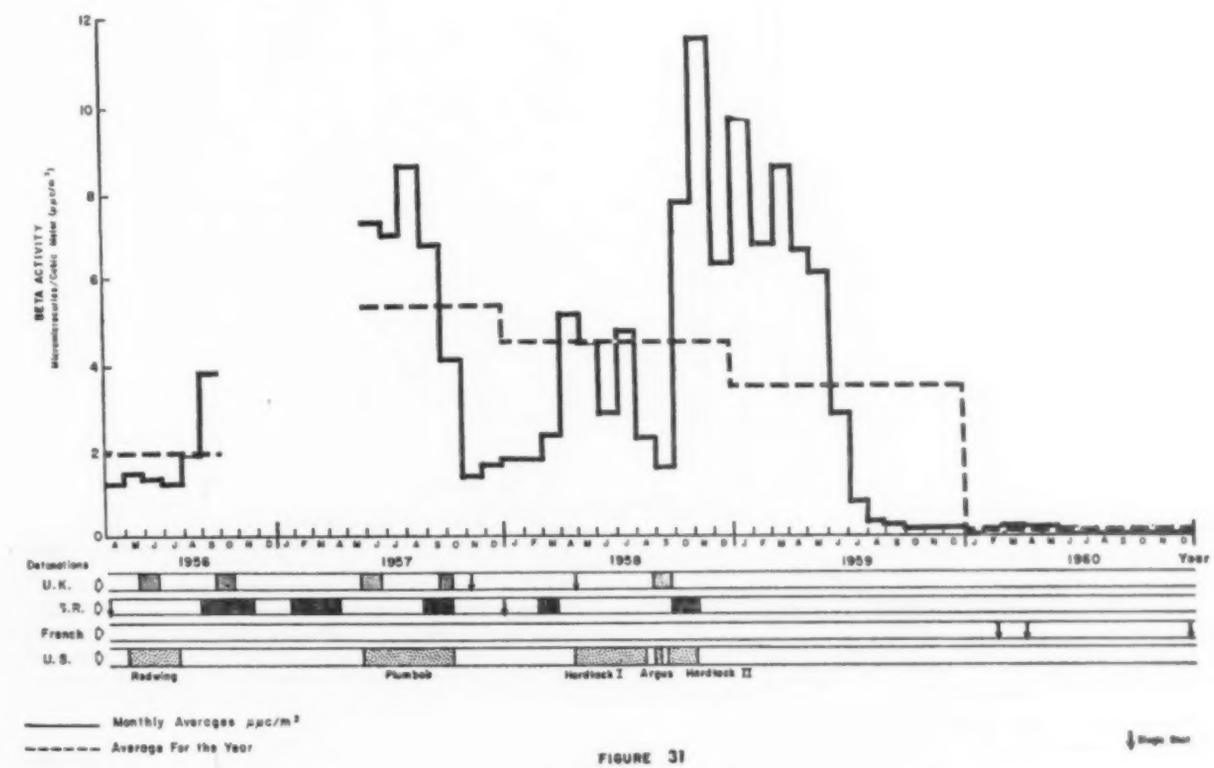


FIGURE 31

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Oklahoma City, Oklahoma

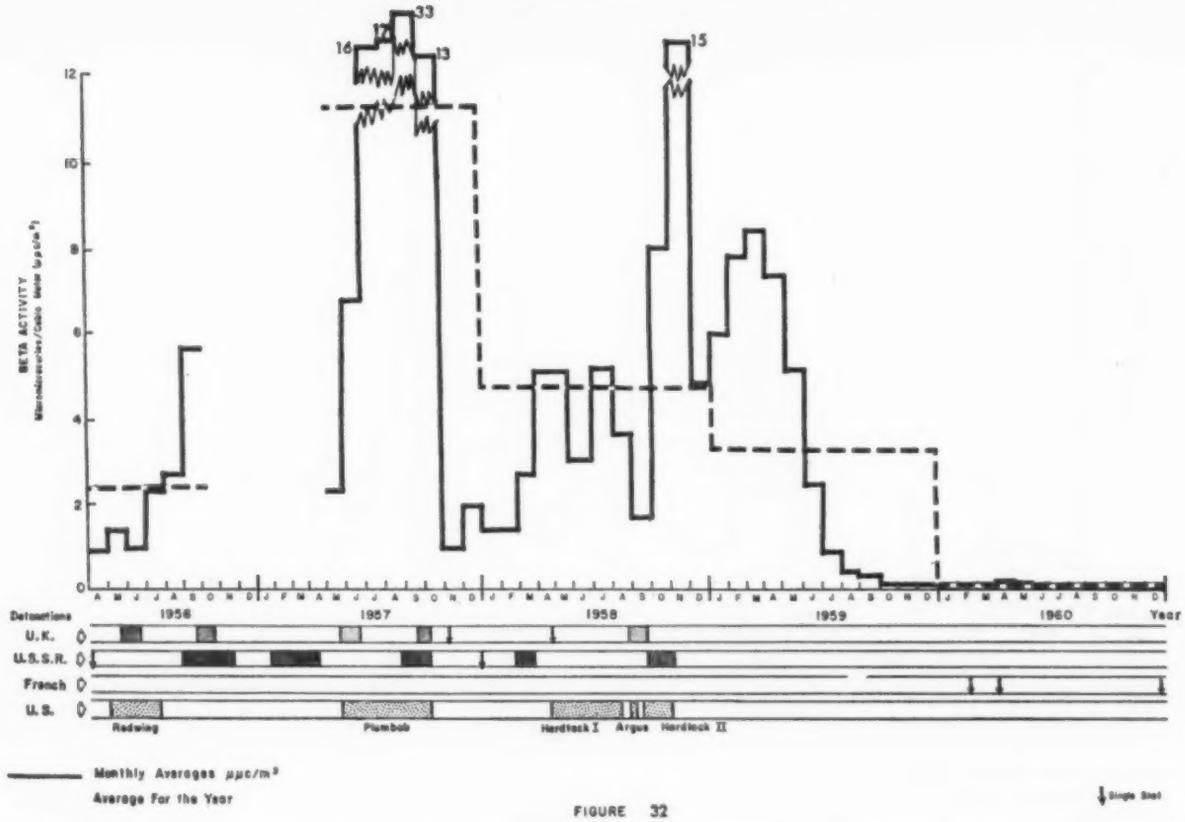


FIGURE 32

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Ponca City, Oklahoma

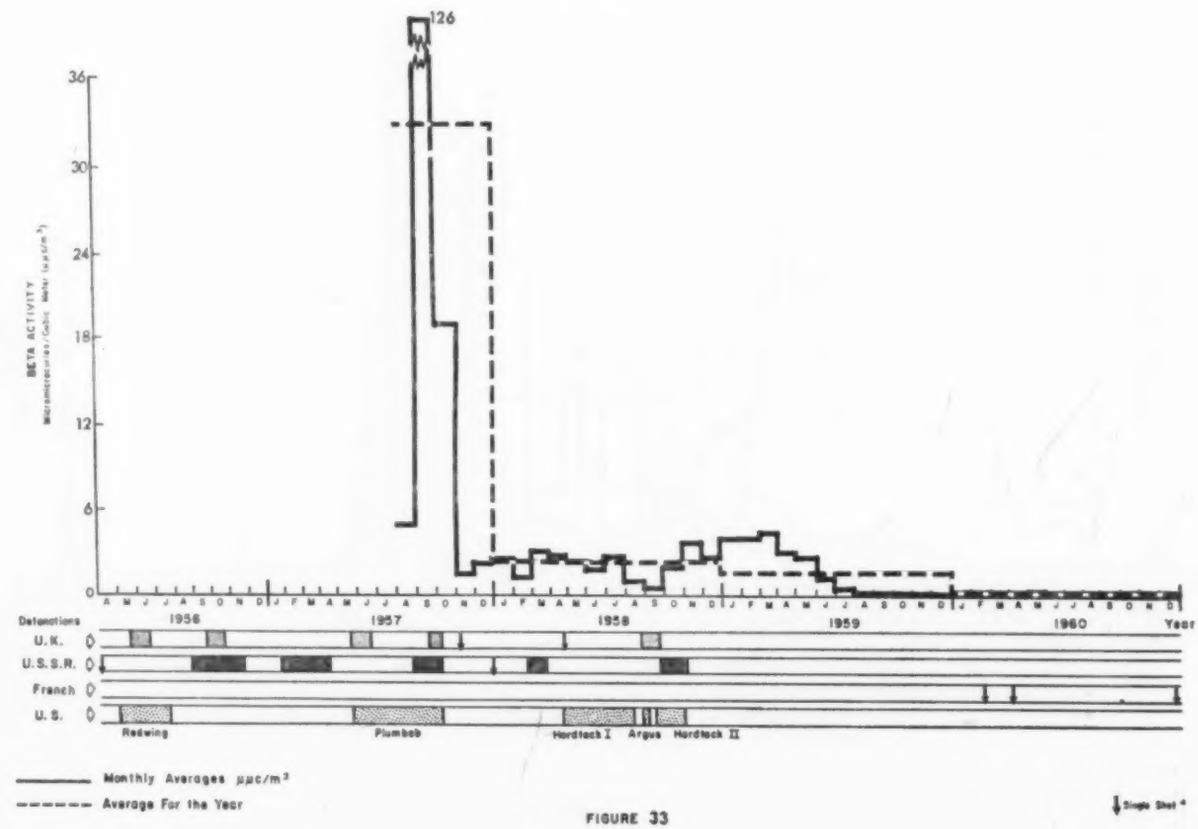


FIGURE 33

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Portland, Oregon

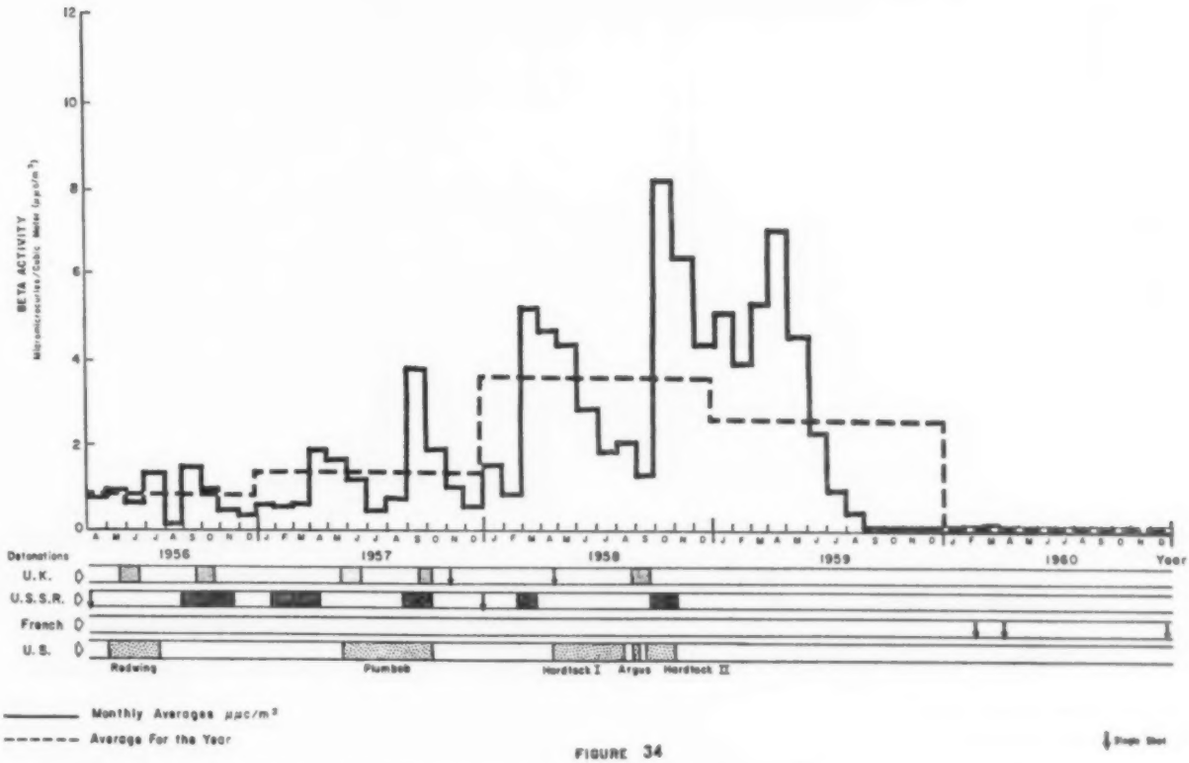


FIGURE 34

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Harrisburg, Pennsylvania

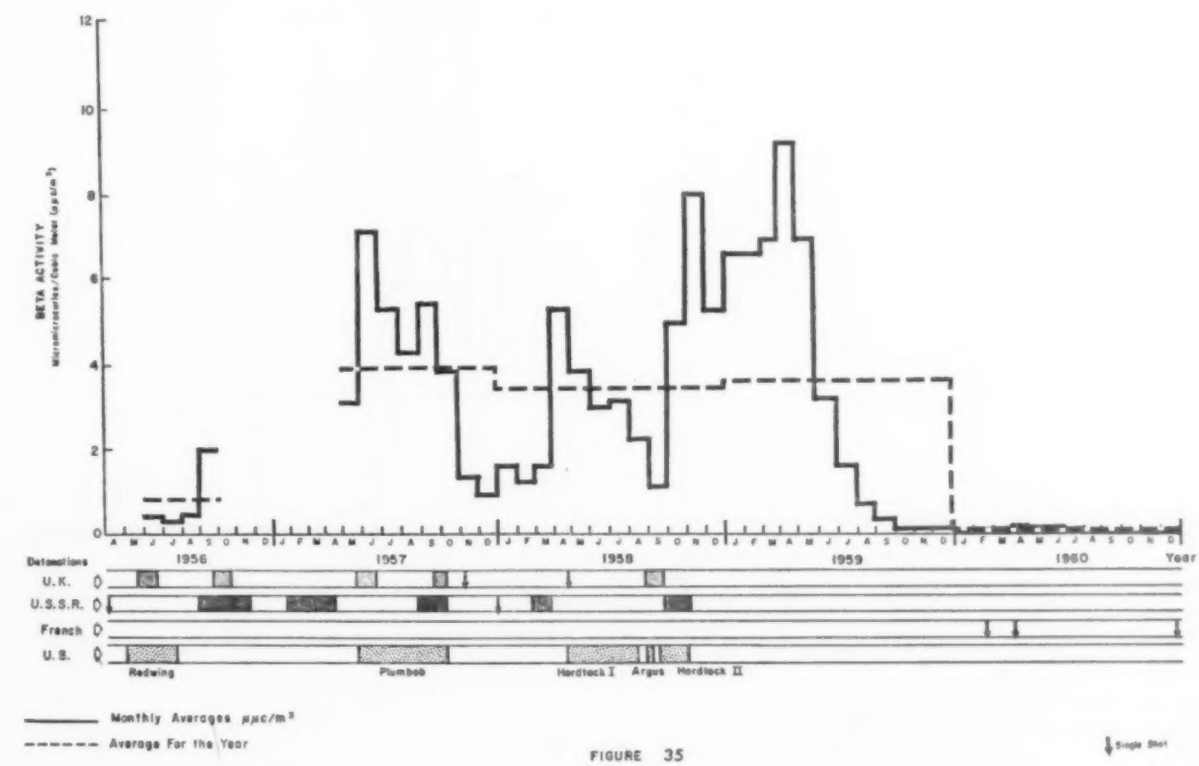


FIGURE 35

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Providence, Rhode Island

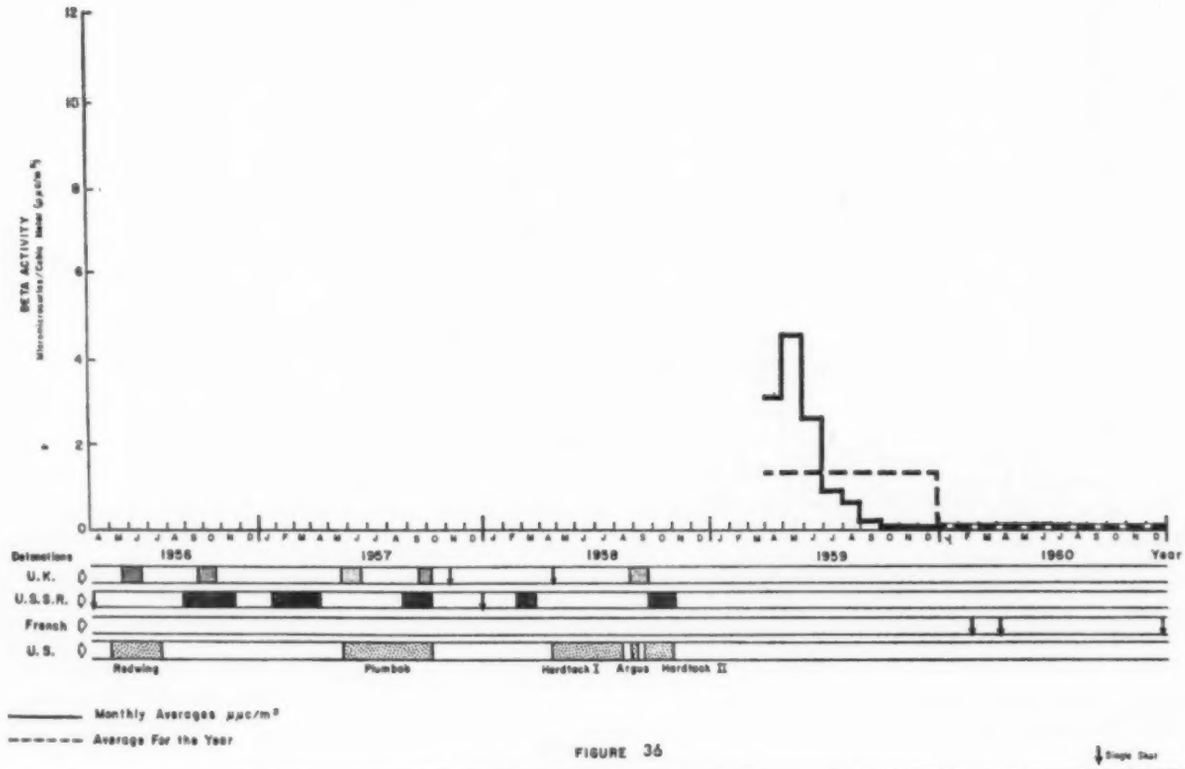


FIGURE 36

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Columbia, South Carolina

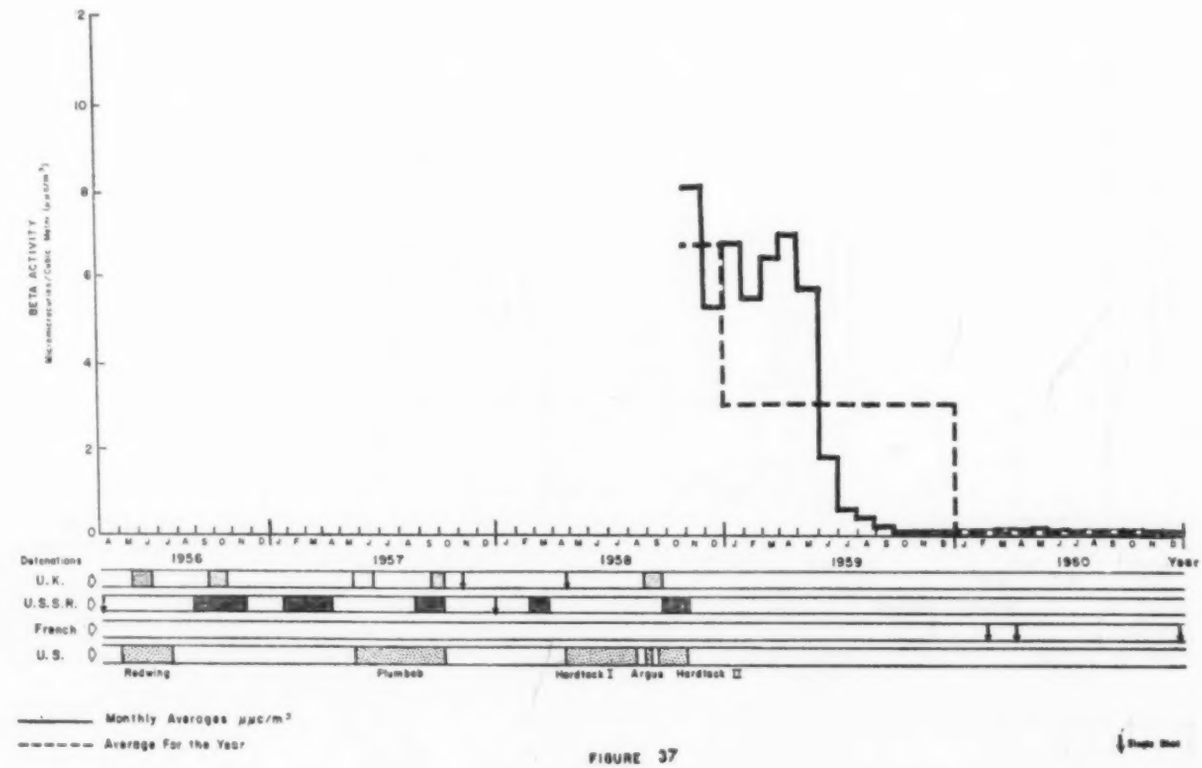


FIGURE 37

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Pierre, South Dakota

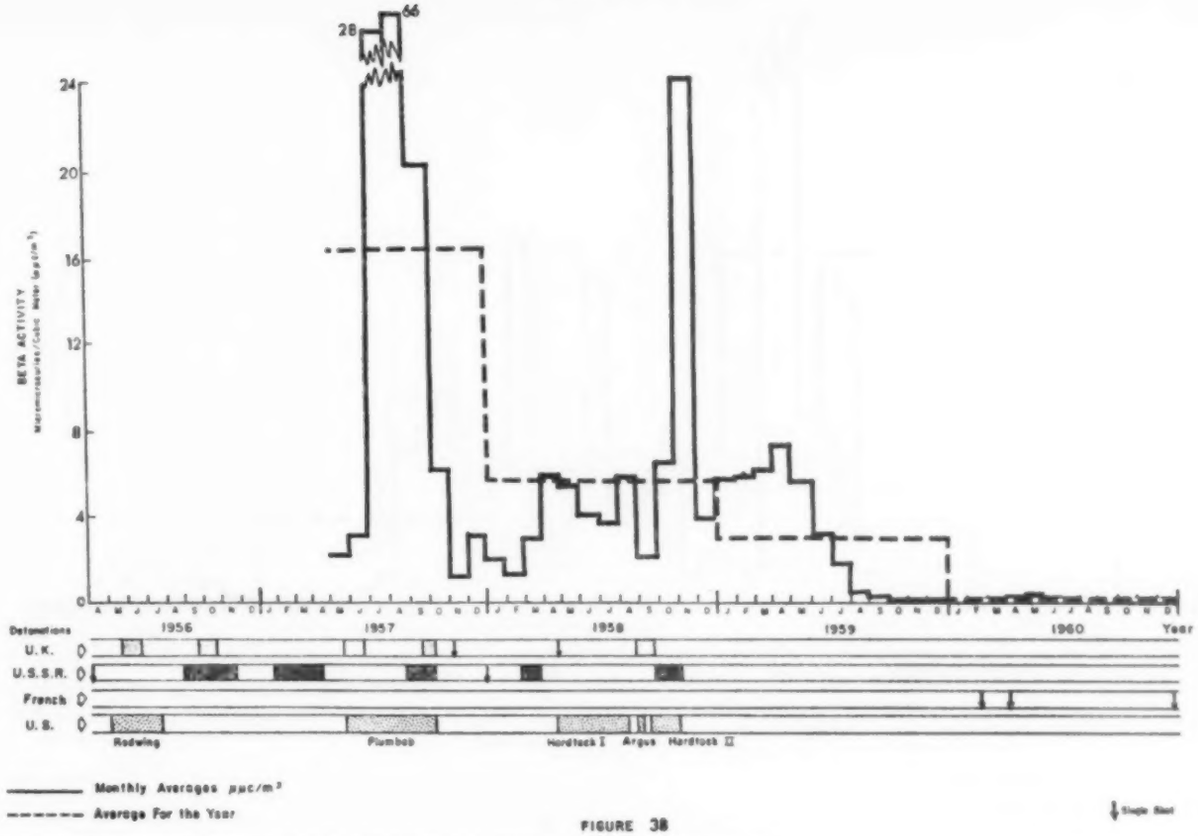


FIGURE 38

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Austin, Texas

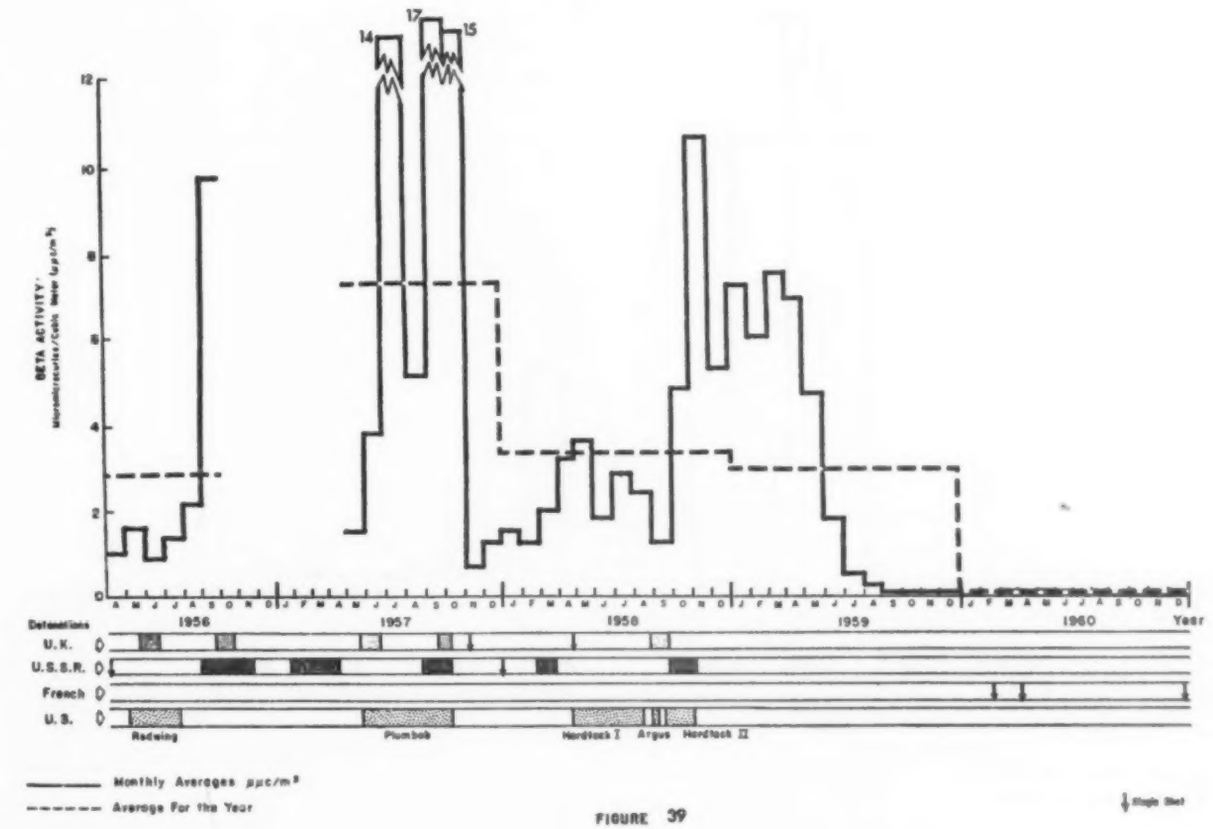


FIGURE 39

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

El Paso, Texas

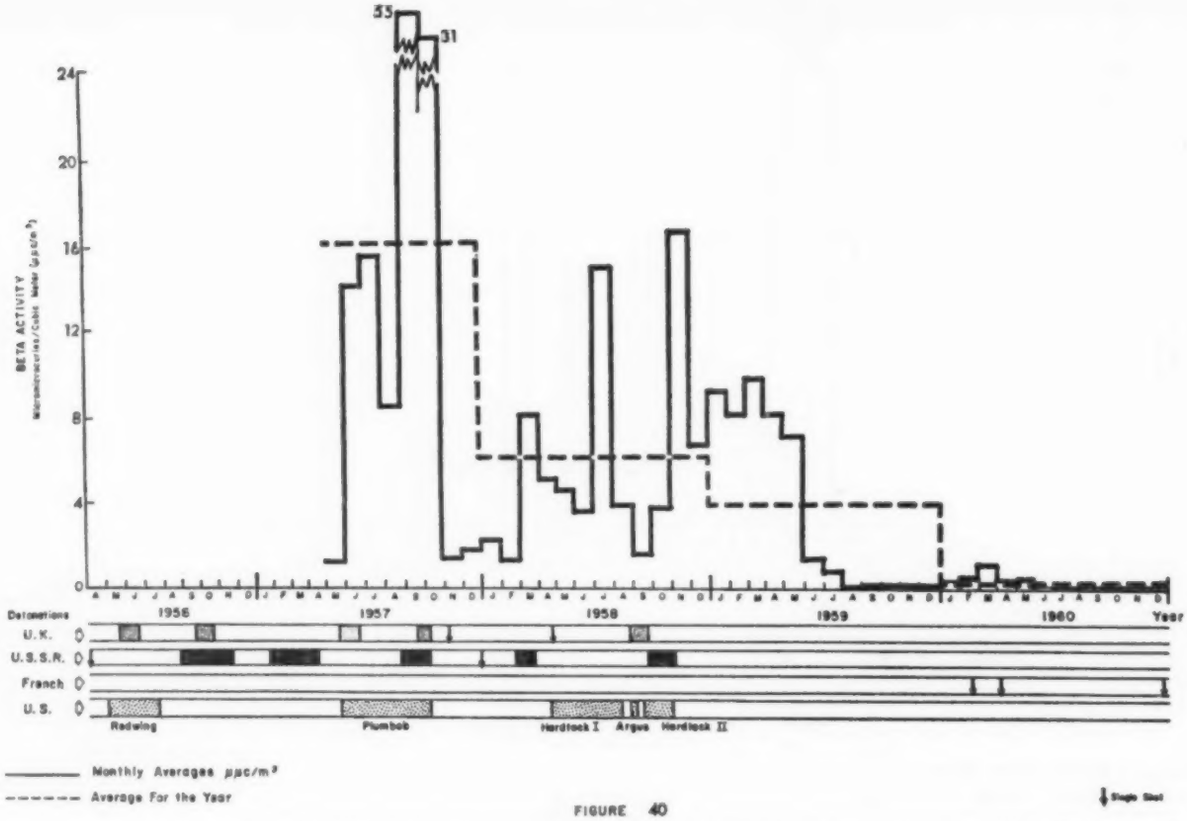


FIGURE 40

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Salt Lake City, Utah

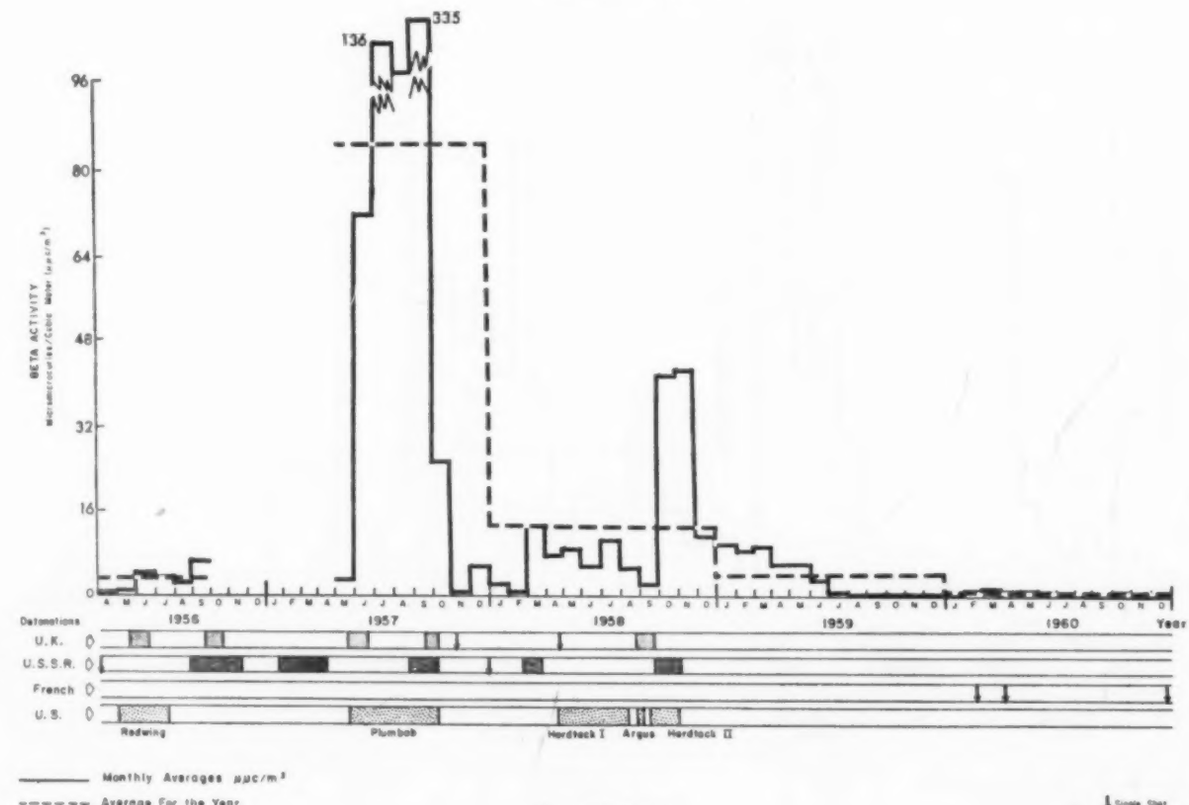


FIGURE 41

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Richmond, Virginia

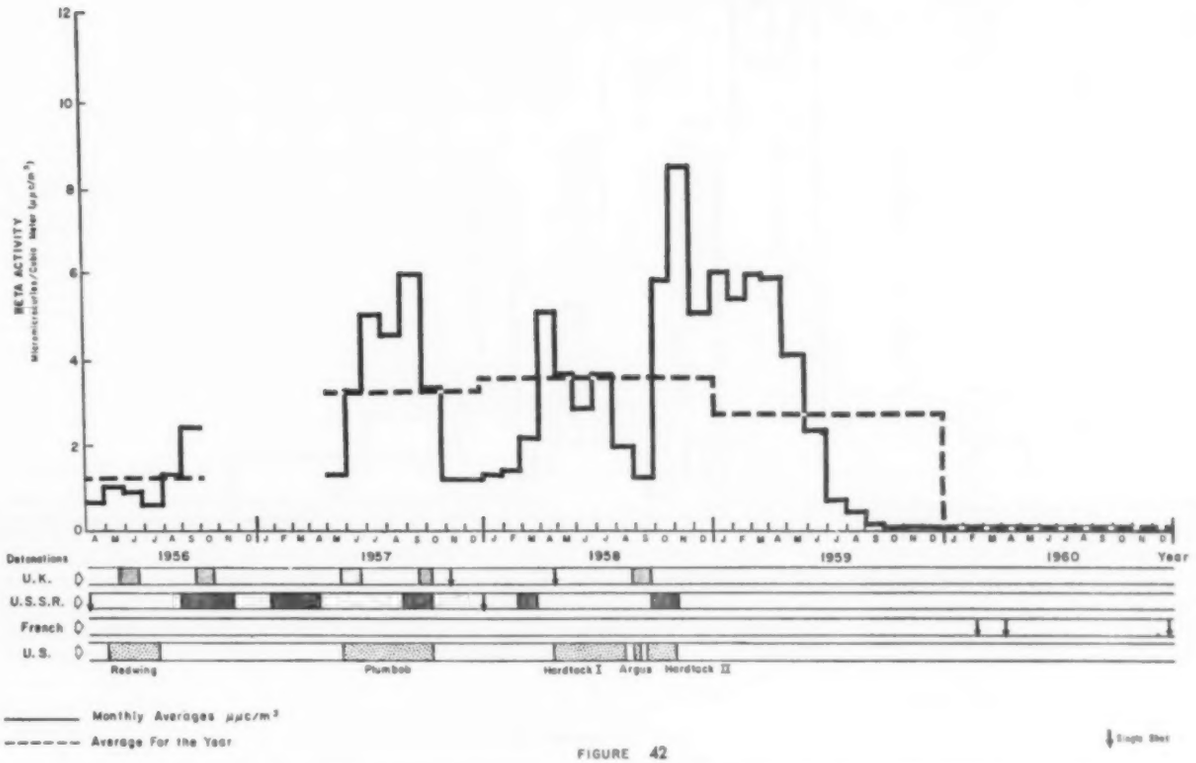


FIGURE 42

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Seattle, Washington

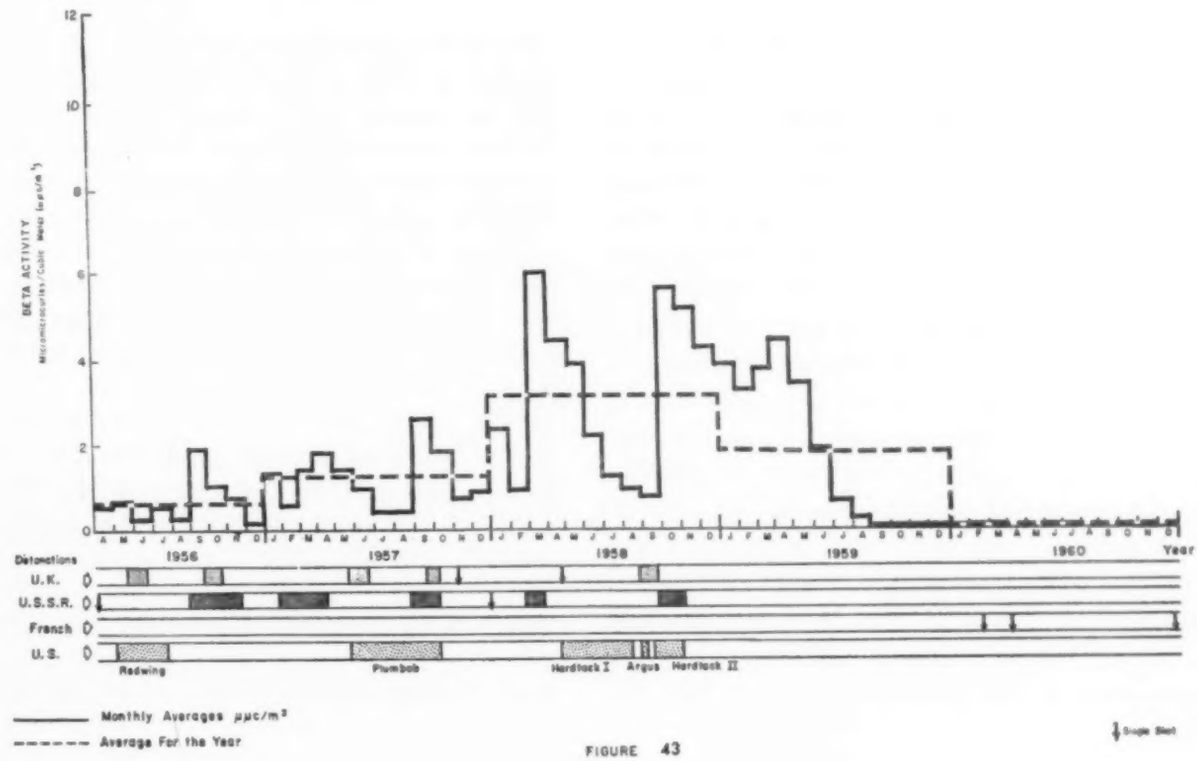


FIGURE 43

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Cheyenne, Wyoming

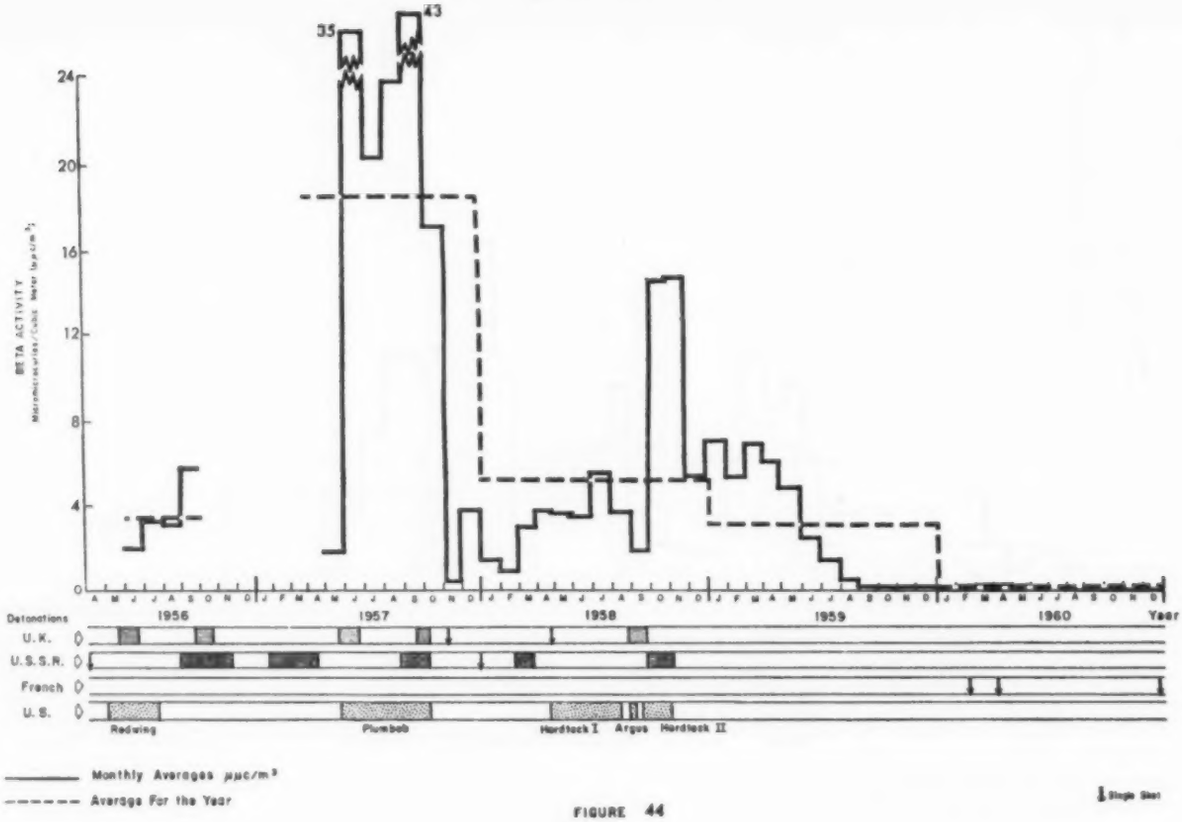


FIGURE 44

TABLE 2.—RADON AND THORON MEASUREMENTS

Radiation Surveillance Network, Public Health Service, Station at Cincinnati, Ohio, February 2–24, 1961

Date	Continuous sample collection			Radon [a] a.m. ($\mu\mu c/m^3$)	Radon-thoron [b] p.m. ($\mu\mu c/m^3$)	Thoron [c] ($\mu\mu c/m^3$)	Beta [d] activity ($\mu\mu c/m^3$)
	Sample change time	Sample period (hours)	Volume (m^3)				
Feb. 2	0830	24.5	29.3	110	450	0.5	0.08
3	0801	23.5	28.1	200	110	0.3	0.04
6	0806	72.1	84.5	350	200	0.3	0.03
7	0805	24.0	28.0	230	120	0.2	0.02
8	0819	24.2	28.3	290	150	0.2	0.07
9	0813	23.9	28.0	530	250	0.8	0.07
10	0815	24.0	28.6	150	130	0.3	0.04
13	0817	72.0	84.2	270	250	0.7	0.07
14	0810	23.9	28.1	80	120	0.4	0.05
15	0814	24.0	28.5	510	100	2.8	0.03
16	0800	23.8	29.3	170	110	1.1	0.04
17	0809	24.1	28.7	340	140	2.9	0.07
20	0805	71.9	85.7	280	200	2.6	0.07
21	0805	24.0	28.9	240	110	1.4	0.06
23	0808	48.0	56.7	90	250	0.9	0.05
24	0806	24.0	28.9	230	80	2.3	0.13
			Average	254	173	1.11	0.06

[a] Radon concentrations are derived from alpha measurements determined immediately after the sampling period (24 to 72 hours) has ceased. Reported radon concentrations have been corrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ± 17 and ± 49 $\mu\mu c/m^3$.

[b] Radon concentrations are derived from alpha measurements made in the afternoon (3 p.m.) approximately 7 hours after the new sampling period has begun. Therefore, the reported values were actually determined one day prior to the date reported here. Reported radon concentrations are uncorrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ± 15 and ± 37 $\mu\mu c/m^3$.

[c] Thoron concentrations are derived from alpha measurements referred to in footnote (a) but are counted 7 hours after the sampling period has ceased. Reported values are corrected to the time of removal of the filter holder. Twice the standard deviation (2σ) falls between ± 0.2 and ± 0.6 $\mu\mu c/m^3$.

[d] Gross beta concentrations are based on measurements made at least 4 days after the end of each sampling period (24 to 72 hours). Twice the standard deviation (2σ) falls between ± 0.01 and ± 0.08 $\mu\mu c/m^3$.

National Air Sampling Network

Division of Air Pollution, Public Health Service

The Public Health Service developed its National Air Sampling Network in 1953 to secure basic data on the nature and extent of air pollution throughout the United States, and to detect trends in levels of pollution with respect to time, location, population density, climate, and other factors associated with air quality.

The current basic network consists of 103 sampling stations operating every year in 66 large cities and 37 nonurban areas. In addition to these every-year stations, 126 cities have stations which operate every other year. Thus, there are 229 sampling stations in all, of which about 166 are active in any given year. A list of National Air Sampling Network Stations appeared in *Radiological Health Data*, Volume 1, Number 2.

The network stations are manned by Federal, State, and local agencies cooperating with the Division of Air Pollution, PHS. Twenty-four hour samples of suspended particulate matter, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a bi-weekly random sampling schedule. The analyses of these samples include the measurement of total quantity of suspended particulate matter, the organic matter soluble in benzene, and fission product gross beta radioactivity. Selected samples are analyzed also for nitrates and sulfates and for a number of metals.

Quarterly reports of individual sample data and annual summaries are distributed to all participating agencies and State health departments. A comprehensive report on the first five years of operation of the Network is contained in the publication, "Air Pollution Measurements of the National Air Sampling Network," Public Health Service Publication No. 637, 1958, for sale by the Superintendent

of Documents, U.S. Government Printing Office, Washington 25, D.C., price $2.00. Gross beta activity data, by States, for the years 1953 through 1958 were submitted by Dr. F. J. Weber, Chief, Division of Radiological Health, Public Health Service, in testimony before the Joint Committee on Atomic Energy—"Hearings on Fallout from Nuclear Weapons Tests," Volume 1, May 1959, pages 173-185.

Previous data on gross beta activities of particulates in air were published in *Radiological Health Data*, Volume I, Numbers 7 and 8, and Volume II, Numbers 1 and 4. Data for the first quarter 1961 are presented in table 1.

FIGURE 1—PUBLIC HEALTH SERVICE NATIONAL AIR SAMPLING NETWORK SAMPLING STATIONS

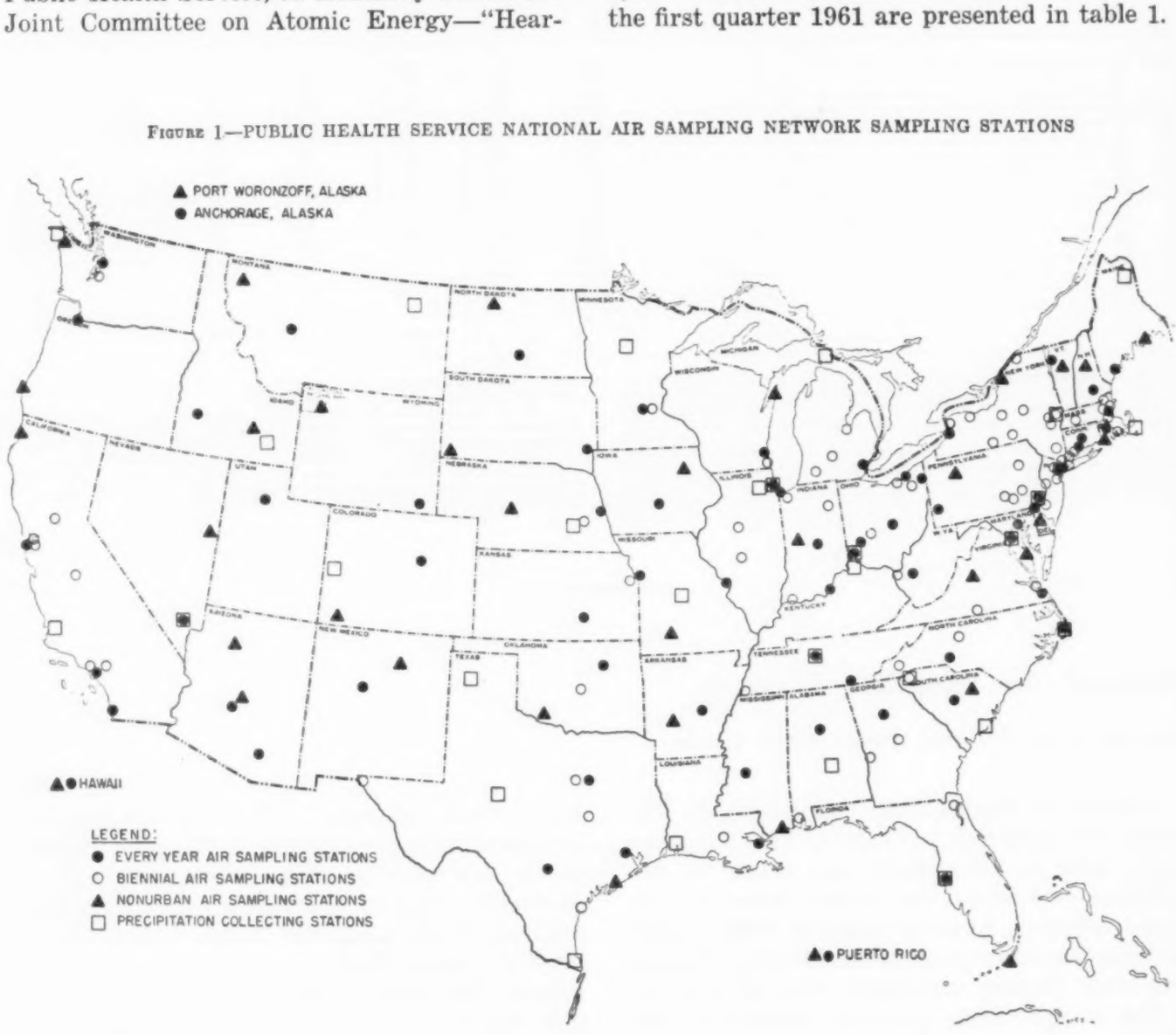


TABLE 1.—GROSS BETA RADIOACTIVITY IN AIR

National Air Sampling Network, Public Health Service, First Quarter 1961

[$\mu\mu$c per cubic meter]

Station location	Number of samples	Minimum	Maximum	Average
Waterbury, Conn	6	<0.1	0.1	<0.1
New Britain, Conn	6	<0.1	0.1	<0.1
Hartford, Conn	7	<0.1	0.1	<0.1
New Haven, Conn	6	<0.1	0.1	<0.1
Portland, Maine	6	<0.1	0.1	0.1
Acadia Nat. Pk., Maine [1]	6	<0.1	0.1	0.1
Boston, Mass	6	<0.1	0.1	0.1
Worcester, Mass	6	<0.1	0.1	<0.1
Brockton, Mass	6	<0.1	0.1	<0.1
Cambridge, Mass	8	<0.1	0.1	0.1
Lowell, Mass	6	<0.1	0.1	0.1
New Bedford, Mass	7	<0.1	0.1	<0.1
Manchester, N. H	6	<0.1	<0.1	<0.1
Coos County, N. H	6	<0.1	0.1	<0.1
Providence, R. I	8	<0.1	0.1	0.1
Washington, Co., R. I. [1]	6	<0.1	0.1	<0.1
Burlington, Vt	6	<0.1	0.1	0.1
Orange County, Vt. [1]	6	<0.1	0.1	0.1
Wilmington, Del	6	<0.1	0.1	<0.1
Kent County, Del [1]	5	<0.1	0.1	<0.1
Atlantic City, N. J	8	<0.1	0.1	0.1
Jersey City, N. J	6	<0.1	0.1	<0.1
Newark, N. J	7	<0.1	0.1	<0.1
Paterson, N. J	5	<0.1	0.1	0.1
New York, N. Y	6	<0.1	0.1	<0.1
Binghamton, N. Y	6	<0.1	0.1	0.1
Syracuse, N. Y	8	<0.1	0.1	<0.1
Utica, N. Y	5	<0.1	0.1	<0.1
Albany, N. Y	6	<0.1	0.1	<0.1
Rochester, N. Y	6	<0.1	0.1	<0.1
Niagara Falls, N. Y	6	<0.1	0.1	0.1
New Rochelle, N. Y	7	<0.1	0.1	0.1
Troy, N. Y	6	<0.1	0.1	0.1
Massena, N. Y	7	<0.1	<0.1	<0.1
Glen Cove, N. Y	5	<0.1	<0.1	<0.1
Elmira, N. Y	6	<0.1	0.1	<0.1
Mt. Vernon, N. Y	8	<0.1	0.1	<0.1
Cape Vincent, N. Y	8	<0.1	0.1	<0.1
Philadelphia, Pa	8	<0.1	0.1	<0.1
Altoona, Pa	4	<0.1	<0.1	<0.1
Erie, Pa	9	<0.1	0.1	<0.1
Pittsburgh, Pa	8	<0.1	0.1	0.1
Allentown, Pa	8	<0.1	0.1	0.1
Johnstown, Pa	5	<0.1	0.1	<0.1
Scranton, Pa	7	<0.1	0.1	0.1
York, Pa	8	<0.1	0.1	<0.1
Bethlehem, Pa	5	<0.1	0.1	<0.1
Clarion County, Pa [1]	7	<0.1	0.1	0.1
Washington, D. C	6	<0.1	0.1	<0.1
Louisville, Ky	6	<0.1	0.1	0.1
Baltimore, Md	5	<0.1	0.1	0.1
Calvert County, Md [1]	6	<0.1	0.1	<0.1
Charlotte, N. C	7	<0.1	0.2	0.1
Greensboro, N. C	7	<0.1	0.1	0.1
Raleigh, N. C	6	<0.1	0.1	0.1
Cape Hatteras, N. C [1]	8	<0.1	0.1	<0.1
San Juan, P. R	6	<0.1	0.1	<0.1
Loquillo, Mtns., P. R. [1]	6	<0.1	0.1	<0.1
Norfolk, Va	7	<0.1	0.1	0.1
Richmond, Va	7	<0.1	0.2	0.1
Hampton, Va	7	<0.1	0.1	0.1
Roanoke, Va	6	<0.1	0.1	0.1
Portsmouth, Va	8	<0.1	0.1	<0.1
Shenandoah, National Park, Va [1]	7	<0.1	0.1	<0.1
Charleston, W. Va	7	<0.1	0.3	0.1
Wheeling, W. Va	7	<0.1	0.1	<0.1
Birmingham, Ala	7	<0.1	0.1	0.1
Montgomery, Ala	7	<0.1	0.1	0.1
Tampa, Fla	7	<0.1	0.1	0.1
Miami, Fla	8	<0.1	0.1	<0.1
Orlando, Fla	6	<0.1	0.1	0.1
St. Petersburg, Fla	6	<0.1	0.1	0.1
Florida Keys, Fla [1]	6	<0.1	0.1	<0.1
Atlanta, Ga	7	<0.1	0.1	0.1
Augusta, Ga	6	<0.1	0.1	<0.1
Savannah, Ga	7	<0.1	0.1	0.1
Jackson, Miss	6	<0.1	0.1	<0.1
Jackson County, Miss [1]	6	<0.1	0.1	.1
Columbia, S. C	6	<0.1	0.1	0.1
Charleston, S. C	7	<0.1	0.2	0.1
Richland, County, S. C [1]	6	<0.1	0.1	0.1
Chattanooga, Tenn	7	<0.1	0.1	0.1
Knoxville, Tenn	6	<0.1	0.1	0.1
Nashville, Tenn	7	<0.1	0.1	0.1
Memphis, Tenn	7	<0.1	0.1	<0.1
Chicago, Ill	6	<0.1	0.1	0.1
East St. Louis, Ill	8	<0.1	0.1	0.1
Rockford, Ill	7	<0.1	0.1	<0.1
East Chicago, Ind	5	<0.1	0.1	0.1
Indianapolis, Ind	6	<0.1	0.1	0.1
Terre Haute, Ind	7	<0.1	0.1	<0.1
Hammond, Ind	7	<0.1	0.1	<0.1
South Bend, Ind	8	<0.1	0.1	<0.1
New Albany, Ind	6	<0.1	0.1	0.1
Montgomery County, Ind [1]	6	<0.1	0.1	0.1
Detroit, Mich	6	<0.1	0.1	0.1
Jackson, Mich	6	<0.1	0.1	0.1
Dearborn, Mich	6	<0.1	0.1	0.1
Cincinnati, Ohio	6	<0.1	0.1	0.1
Youngstown, Ohio	8	<0.1	0.1	<0.1
Canton, Ohio	7	<0.1	0.1	<0.1
Cleveland, Ohio	6	<0.1	0.1	0.1
Columbus, Ohio	7	<0.1	0.1	0.1
Toledo, Ohio	5	<0.1	0.1	<0.1
Akron, Ohio	6	<0.1	0.1	0.1
Dayton, Ohio	5	<0.1	0.1	<0.1
Hamilton, Ohio	6	<0.1	0.1	0.1
Milwaukee, Wis	6	<0.1	0.1	<0.1
Madison, Wis	7	<0.1	<0.1	<0.1
Door County, Wis [1]	6	<0.1	0.1	<0.1
Des Moines, Iowa	8	<0.1	0.1	0.1
Davenport, Iowa	8	<0.1	0.1	<0.1
Clayton County, Iowa [1]	8	<0.1	0.1	0.1
Wichita, Kans	7	<0.1	0.1	0.1
Topeka, Kans	8	<0.1	0.1	0.1
Minneapolis, Minn	6	<0.1	<0.1	<0.1
Duluth, Minn	6	<0.1	<0.1	<0.1
St. Paul, Minn	7	<0.1	0.1	<0.1
Kansas City, Mo	6	<0.1	0.1	0.1
St. Louis, Mo	7	<0.1	0.1	0.1
Shannon County, Mo [1]	8	<0.1	0.1	<0.1
Omaha, Nebr	8	<0.1	0.2	0.1
Thomas County, Nebr	6	<0.1	0.1	<0.1
Bismarck, N. D	5	<0.1	0.1	<0.1
Ward County, N. D [1]	5	<0.1	<0.1	<0.1
Sioux Falls, S. D	8	<0.1	0.1	<0.1
Black Hills Forest, S. D [1]	6	<0.1	0.1	0.1
Little Rock, Ark	5	<0.1	0.1	0.1
Montgomery County, Ark [1]	6	<0.1	0.1	0.1
New Orleans, La	8	<0.1	0.1	0.1
Shreveport, La	7	<0.1	0.1	0.1
Albuquerque, N. M	7	0.1	0.1	0.1
Colfax County, N. M [1]	6	<0.1	0.1	0.1
Tulsa, Okla	8	<0.1	0.1	0.1
Oklahoma City, Okla	6	<0.1	0.1	0.1
Cherokee County Okla [1]	6	<0.1	0.1	0.1
Houston, Tex	6	<0.1	0.1	0.1
Dallas, Tex	4	<0.1	0.1	<0.1
San Antonio, Tex	6	<0.1	0.1	<0.1
Austin, Tex	6	<0.1	0.1	0.1
Beaumont, Tex	8	<0.1	0.1	0.1
Galveston, Tex	6	<0.1	0.1	0.1
Calhoun County, Tex [1]	3	<0.1	0.1	0.1
Denver, Col	7	<0.1	0.1	0.1
Montezuma County, Col [1]	6	<0.1	0.1	0.1
Boise, Idaho	7	<0.1	0.3	0.1
Butte County, Idaho [1]	6	<0.1	0.3	0.1
Helena, Mont	7	<0.1	0.1	0.1
Glacier National Park, Mont [1]	6	<0.1	0.1	<0.1
Salt Lake City, Utah	6	<0.1	0.1	0.1
Cheyenne, Wyo	7	<0.1	0.1	<0.1
Yellowstone Park, Wyo [1]	8	<0.1	0.1	<0.1
Anchorage, Alaska	6	<0.1	0.1	0.1
Pt Woronzof Alaska [1]	6	<0.1	0.1	<0.1
Phoenix, Ariz	7	0.1	0.2	0.1
Tuscon, Ariz	6	0.1	0.1	0.1
Maricopa County, Ariz [1]	6	<0.1	0.1	0.1
Grand Canyon Park, Ariz [1]	7	<0.1	0.1	0.1
Los Angeles, Calif	7	<0.1	0.2	0.1
San Francisco, Calif	6	<0.1	0.1	<0.1
Berkeley, Calif	6	<0.1	0.1	<0.1
San Jose, Calif	6	<0.1	0.2	0.1
San Diego, Calif	5	<0.1	0.1	0.1
San Bernardino, Calif	6	<0.1	0.2	0.1
Oakland, Calif	7	<0.1	0.1	<0.1
Long Beach, Calif	7	<0.1	0.1	<0.1
Glendale, Calif	6	<0.1	0.1	0.1
Humboldt County, Cal [1]	6	<0.1	<0.1	<0.1
Honolulu, Hawaii	6	<0.1	0.1	<0.1
Kahaluu, Hawaii [1]	7	<0.1	<0.1	<0.1
Las Vegas, Nev	7	<0.1	0.1	0.1
White Pine County, Nev [1]	8	<0.1	0.1	<0.1
Portland, Oreg	7	<0.1	0.1	<0.1
Eugene, Oreg	5	<0.1	<0.1	<0.1
Medford, Oreg	6	<0.1	0.2	0.1
Curry County, Oregon [1]	4	<0.1	0.1	0.1
Seattle, Wash	6	<0.1	0.1	<0.1
Spokane, Wash	6	<0.1	0.1	0.1
Clallam County, Wash [1]	4	<0.1	<0.1	<0.1

[1] Nonurban station.

Gross Beta Radioactivity In Precipitation

National Air Sampling Network, Precipitation Collection Section, Public Health Service

During 1959 a precipitation collection and analysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio, and the National Air Sampling Network. The collection stations are located at Weather Bureau offices or airport stations. Monthly composite samples of precipitation are collected at 30 stations and forwarded to the Network laboratory for analysis. A list of these precipitation collection stations is given below. Samples are analyzed for total solids and a large number of metals and nonmetals. In addition, samples representing 85 percent or more of the official rainfall recorded at the collecting stations are analyzed for fission product gross beta radioactivity if a large enough volume remains after the requirements for the chemical analysis have been met.

PRECIPITATION COLLECTION STATIONS

National Air Sampling Network

Alabama: Montgomery
California: Santa Maria
Colorado: Grand Junction
Florida: Tampa
Idaho: Pocatello
Illinois:
  Chicago (Midway Airport)
  Chicago (O'Hare Airport)
Louisiana: Lake Charles
Maine: Caribou
Maryland: Silver Hill
Massachusetts: Nantucket
Michigan: Sault Ste. Marie
Minnesota: St. Cloud
Missouri: Columbia
Montana: Glasgow
Nebraska: Grand Island
Nevada: Las Vegas
New York: Albany
North Carolina: Cape Hatteras
Ohio:
  Cincinnati (research station)
  Cincinnati (airport)
Pennsylvania: Philadelphia
South Carolina:
  Charleston
  Greenville
Tennessee: Nashville
Texas:
  Brownsville
  San Angelo
  Amarillo
Virginia: Sterling
Washington: Tatoosh Island

TABLE 1.—GROSS BETA RADIOACTIVITY OF PRECIPITATION

National Air Sampling Network, Public Health Service, First Quarter 1961

Station	January		February		March	
	μμc/liter	μμc/m²	μμc/liter	μμc/m²	μμc/liter	μμc/m²
Albany, N. Y.	[a]	[a]	[a]	[a]	18	1,300
Amarillo, Tex.	[a]	[a]	[a]	[a]	19	1,100
Cape Hatteras, N. C.	[a]	[a]	8	600	10	700
Caribou, Maine	[a]	[a]	10	900	15	[1,000
Charleston, S. C.	[a]	[a]	7	700	9	1,600
Cincinnati, Ohio: (Airport)	[a]	[a]	10	900	[a]	[a]
(WBRS)	[a]	[a]	11	1,000	37	4,200
Columbia, Mo.	[a]	[a]	[a]	[a]	16	1,800
Greenville, S. C.	[a]	[a]	6	1,000	[a]	[a]
Lake Charles, La.	11	1,500	4	700	6	600
Montgomery, Ala.	8	400	2	800	10	2,700
Nantucket, Mass.	[a]	[a]	[a]	[a]	19	1,900
Nashville, Tenn.	[a]	[a]	7	900	[a]	[a]
San Angelo, Tex.	9	800	[a]	[a]	[a]	[a]
Sault Ste. Marie, Mich.	[a]	[a]	[a]	[a]	25	1,700
Sterling, Va.	[a]	[a]	13	1,300	[a]	[a]
Tampa, Fla.	[a]	[a]	6	500	[a]	[a]
Tatoosh, Wash.	[a]	[a]	6	2,900	10	2,000

[a] No data available due to low collection efficiency or inadequate sample.

Radioactivity Measurements In Air

U.S. Naval Research Laboratory

Radioactivity measurements of air-filter samples collected at various sites near the 80th Meridian (West) are made by the U.S. Naval Research Laboratory under a program partially financed by the Atomic Energy Commission.

The daily record of fission product beta activity during February 1961 is presented in table 1, and the radioactivity profile for the same month is shown in figure 1. This figure now illustrates the data plotted in semilogarithmic coordinates. Previously the data was presented in rectangular coordinates with the abscissa expressed in disintegrations per minute per cubic meter. The concentrations in table 1 are expressed in disintegrations per minute per cubic meter of air at the collecting site (2.2 disintegrations per minute per cubic meter equals 1 micromicrocurie per cubic meter).

Figure 1.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENTS OF SURFACE AIR AT STATIONS NEAR THE 80th MERIDIAN (WEST), U.S. Naval Research Laboratory, (February 1961)

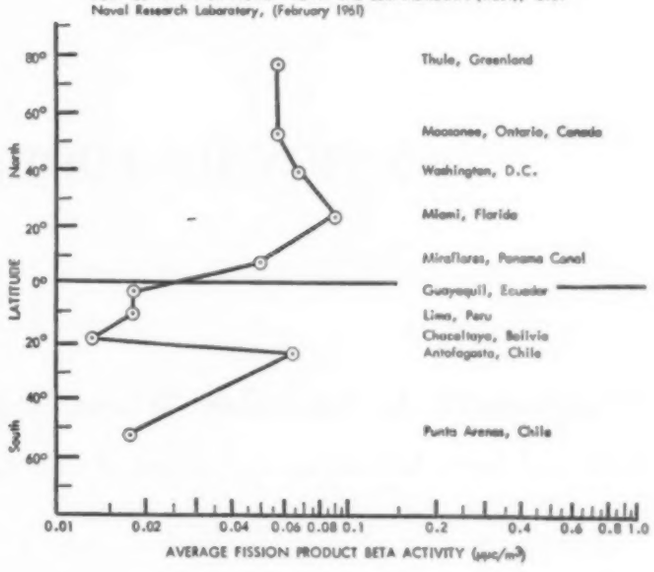


TABLE 1.—DAILY RECORD OF FISSION PRODUCT BETA ACTIVITY COLLECTED BY AIR FILTRATION

U.S. Naval Research Laboratory, February 1961

[dpm/m³]

Day	Punta Arenas, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal Zone	Mauna Loa, Hawaii	Miami, Florida	Washington D. C.	Moosonee, Canada Ontario,	Thule, Greenland
1	0.05	0.21	----	0.01	0.03	0.11	0.06	0.18	0.19	----	0.11
2	0.02	0.21	----	0.01	0.02	0.08	0.08	0.18	0.11	----	0.11
3	0.02	0.21	----	0.01	----	0.08	0.08	0.18	0.11	----	0.13
4	0.02	----	----	0.02	0.06	0.07	0.06	0.14	0.09	----	0.13
5	0.02	----	----	0.02	0.03	0.07	0.06	0.14	0.09	----	0.10
6	0.02	----	0.02	0.02	0.04	0.07	0.06	0.14	0.09	----	0.10
7	0.03	0.13	0.02	0.06	0.03	0.07	0.05	0.15	0.18	----	0.10
8	0.03	0.13	0.04	0.06	0.03	0.07	0.05	0.15	0.18	----	0.13
9	0.04	0.12	0.01	0.04	0.03	0.10	0.06	0.15	0.21	----	0.13
10	0.04	0.12	0.02	0.04	0.02	0.10	0.06	0.15	0.21	----	0.17
11	0.05	0.09	0.01	0.02	0.02	0.08	0.11	0.24	0.18	----	0.17
12	0.05	0.09	0.03	0.02	0.02	0.08	0.11	0.24	0.18	----	0.14
13	0.05	0.09	0.01	0.02	0.03	0.08	0.11	0.24	0.18	----	0.14
14	0.08	0.15	0.01	0.12	0.02	0.09	0.11	0.31	0.19	----	0.14
15	0.08	0.15	0.00	0.12	0.03	0.09	0.11	0.31	0.19	----	0.12
16	----	----	0.04	----	0.03	0.16	0.22	0.31	0.15	----	0.12
17	----	----	0.05	----	----	0.16	0.22	0.31	0.15	----	0.14
18	----	0.16	0.04	----	0.03	0.21	0.03	0.17	0.16	----	0.14
19	----	0.16	0.04	----	0.03	0.21	0.03	0.17	0.16	----	0.13
20	----	0.16	0.02	----	0.03	0.21	0.03	0.17	0.16	----	0.13
21	----	----	0.03	0.06	----	0.16	0.04	0.13	0.11	----	0.13
22	----	----	0.04	0.06	0.07	0.16	0.04	0.13	0.11	----	0.12
23	----	----	0.03	----	0.03	0.15	0.10	0.12	0.08	----	0.12
24	----	----	0.03	----	0.06	0.15	0.10	0.12	0.08	----	0.13
25	----	----	0.03	0.03	----	0.08	0.08	0.25	0.20	0.11	0.13
26	----	----	0.04	0.03	----	0.08	0.08	0.25	0.20	0.11	0.11
27	----	----	0.05	0.03	0.09	0.08	0.08	0.25	0.20	0.11	0.11
28	----	0.15	0.04	0.05	0.04	0.10	0.07	0.31	0.16	0.20	0.11
Mean value	0.04	0.14	0.03	0.04	0.04	0.11	0.08	0.20	0.15	0.13	0.13

SECTION II.—FOOD, OTHER THAN MILK

Strontium-90 In Canadian Wheat Samples

Health and Safety Laboratory, U.S. Atomic Energy Commission

Strontinum-90 and calcium levels in wheat from a number of foreign countries, reported by the Health and Safety Laboratory were presented in *Radiological Health Data*, Volume II, Number 4. Analyses of a set of samples representing wheat grown in Canada during 1958 and 1959 have now been completed. The results of table 1 [1] are seen to be of the same order of magnitude and variability as those found for United States wheat grown in the same years.

TABLE 1.—STRONTIUM-90 AND CALCIUM CONTENT OF CANADIAN WHEAT

Year	Number of samples	Calcium				Strontium-90							
		gm/kg original material				$\mu\mu$c/gm Ca				$\mu\mu$c/kg original material			
		Mean	Std. dev.	Min.	Max.	Mean	Std. dev.	Min.	Max.	Mean	Std. dev.	Min.	Max.
1958	5	0.26	0.06	0.16	0.30	85	31	39	123	24	8	11	31
1959	48	0.33	0.12	0.23	0.91	124	37	38	185	39	10	12	57

[1] Data from *Quarterly Summary Report, HASL-III*, April 1, 1961.

SECTION III.—MILK

Milk Monitoring Program

Division of Radiological Health, Public Health Service

There are two Public Health Service Milk Monitoring Programs. The original network consisted of five milkshed sampling stations. It was later expanded to twelve stations, nine of which are still active. Raw milk is spot sampled at these stations. During 1960 a new sampling program of 60 stations was established. Processed milk is sampled at these stations. Since the sampling procedures for the raw milk sampling stations and the processed milk area sampling stations are different, they are described and reported separately. The Public Health Service Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, continues to conduct the analyses for the original network stations; the Public Health Service Southeastern Radiological Health Laboratory at Montgomery, Ala., and the Southwestern Radiological Health Laboratory at Las Vegas, Nev., provide analytical services for the new program.

The purposes of the two sampling programs are not the same. The original network was established to develop sampling and radiochemical analytical proficiencies under conditions which would remain similar over a period of time in regard to the source of milk. During the operation of this program it became apparent that a broader sampling program, more directly related to the milk consumed by the population, was necessary. The Public Health Service and the Department of Health, Education, and Welfare acted to provide facilities for this change. This resulted in the transition from the program of sampling raw milk, collected from milksheds of limited size, to a sampling program designed to be representative of the processed milk consumed in a given municipality.

In some instances, the newly designated stations are the same as those which were reported originally. The establishment of the new processed milk area sampling stations does not preclude the need for further raw milk sampling from the selected milkshed serving the same city. It is important that both networks be in operation for a sufficient period of time to provide an overlap for the purpose of comparative study.

Because of the different sources of these samples, changes in the method of collecting samples, and the utilization of different laboratory techniques, differences were anticipated in the amounts of radioactivity found in the milk under the two programs. For this reason, an investigation to determine the comparability of the two programs was begun in January 1961. This investigation covers many factors, including laboratory methodology and collection methods. Until this study has been completed and additional experience has been gained under the new program, no valid interpretation

can be made of any differences of radioactivity in milk samples collected under the two systems.

Publication of the data from each program will normally follow about four months after sample collection because of the time required for shipment, processing, decay product build-up, compilation of the data, and clearance and publication procedures.

Raw Milk Sampling Stations

The initial purpose of establishing this network was in keeping with the normal and continuing program of the Public Health Service to determine trends in our changing environment with respect to measuring the amounts of radioactivity in water, air, milk, and other foods. Milk was the food chosen for initial testing because it is among the most important components of the diet and is available at all seasons of the year and in all climates. A primary objective was to develop effective collection systems and radiochemical analysis procedures which would make them more suitable for larger scale programs.

The criteria on which the selection of the original sampling stations was based appeared in the discussion sections of all Volume I issues of *Radiological Health Data.*

One-gallon raw milk samples are collected from a dairy company once each month and forwarded by air parcel post to the Robert A. Taft Sanitary Engineering Center for radionuclide analyses. These samples represent between 2,000 and 90,000 gallon lots. The concentrations of iodine-131, barium-140, cesium-137, and naturally-occurring potassium-40 are all currently being measured by gamma scintillation spectroscopy. Total radiostrontium and strontium-90 are determined following radiochemical separations. The amount of strontium-90 is calculated by measuring the build-up of the strontium-90 daughter decay product, yttrium-90, over a two-week period. Measurements are made in a low background anticoincidence beta counter. The total radioactive strontium is counted in a shielded internal proportional counter. The difference between the total strontium-90 is reported as strontium-89. Stable calcium is also determined.

The April through September 1960 issues of *Radiological Health Data* list references for technical descriptions of the methodology of analyses used.

February 1961 data for the raw milk sampling stations are presented in table 1.

Processed Milk Sampling Stations

The new milk surveillance program will provide additional information on levels of radioactivity in milk consumed by the public. The new stations have been established in cooperation with State and local health and milk sanitation agencies. Each city has been selected to provide adequate coverage with respect to production areas and the consuming population. The emphases of this expanded sampling and radioassay program are—

1. Measuring the levels of radioactivity of the milk consumed by the public in various regions of the country by obtaining samples of pasteurized and homogenized milk at the processing plant, and
2. Providing one sampling point within each State with additional points when indicated by widely varying conditions of the milk supply or the need to provide coverage of large population groups. This differs from the original set of sampling stations whose selection was based principally upon certain criteria involving milk production and milkshed area characteristics.

The new network was designed to sample processed milk rather than the raw product. The sampling procedure was developed to provide a sample from one day's sales per month in a community which would be as representative of the total supply as can be achieved under practical conditions. Each sample is a composite of those plants supplying not less than 90 percent of a city's milk supply. The contribution from each plant to the total sample is approximately proportional to the volume of milk sold.

The samples from the new stations are collected with the assistance of the various State and local health and milk sanitation agencies and are shipped for analyses to either the Southwestern or Southeastern Radiological Health Laboratory. The Southeastern Radiological Health Laboratory processes samples

from the 30 states generally east of the Mississippi, and the Southwestern Radiological Health Laboratory processes samples from the western states. Figure 1 shows the locations of these stations.

At the present time radioassays for Sr^{90}, Cs^{137}, Sr^{89}, Ba^{140}, and I^{131} are being performed. The latter three isotopes are below present limits of detection. The lower levels of detection for Sr^{89} is 5 $\mu\mu c$/liter, and for Ba^{140} and I^{131}, 10 $\mu\mu c$/liter. Other radionuclides of concern to public health agencies will be included for assay as necessary for more complete monitoring of the milk supply.

The St. George, Utah, sample is collected as part of the monitoring program around the Nevada Test Site. Because it does not fulfill the processed milk sampling criteria, it will no longer be reported as part of this surveillance program.

February 1961 data from the two laboratories are presented in table 2.

TABLE 1.—RADIOACTIVITY IN MILK—RAW MILK SAMPLING STATIONS

Public Health dervice, Milk Monitoring Program, Robert A Taft Sanitary Engineering Center, February 1961

[Radioactivity concentrations in $\mu\mu c$/liter]

Area	Calcium (grams/liter)		Strontium-90		Cesium-137		Area	Calcium (grams/liter)		Strontium-90		Cesium-137	
	February	Yearly average	February	Yearly average	February	Yearly average		February	Yearly average	February	Yearly average	February	Yearly average
Atlanta, Ga	1.17	1.14	15	14	25	30	Sacramento, Calif.	1.22	1.14	7	4	10	10
Austin, Tex	1.12	1.11	5	4	10	10	Salt Lake City, Utah.	1.15	1.12	6	6	10	20
Chicago, Ill	1.20	1.12	6	9	20	25							
Cincinnati, Ohio	1.22	1.16	8	9	15	20	Spokane, Wash	1.18	1.13	9	10	15	30
New York, N. Y.	1.08	1.10	9	9	20	20	St. Louis, Mo	1.24	1.20	12	17	20	25

Note: I^{131} and Ba^{140} below detectable limits for all samples collected in February. These limits are 10 $\mu\mu c$/liter for I^{131} and Ba^{140}, and 5 $\mu\mu c$/liter for Sr^{89}.

FIGURE 1.—PROCESSED MILK AREA SAMPLING STATIONS

TABLE 2.—RADIOACTIVITY IN MILK—PROCESSED MILK AREA SAMPLING STATIONS, FEBRUARY 1961

(Radioactivity concentrations in $\mu\mu c$/liter)

Area	Calcium (grams/liter)		Strontium-90		Cesium-137		Area	Calcium (grams/liter)		Strontium-90		Cesium-137	
	February	Average to Date	February	Average to Date	February	Average to Date		February	Average to Date	February	Average to Date	February	Average to Date
Albuquerque, N. Mex.	1.03	1.10	4	4	<5	<5	Memphis, Tenn	1.32	1.28	8	9	<5	<5
Atlanta, Ga	1.24	1.24	6	9	15	<5	Milwaukee, Wis	1.20	1.18	4	6	<5	<5
Austin, Tex	1.19	1.20	2	2	<5	<5	Minneapolis, Minn	0.95	1.03	8	8	5	<5
Baltimore, Md	1.20	1.21	6	7	<5	<5	New Orleans, La	1.25	1.26	6	12	<5	<5
Boston, Mass	1.28	1.21	10	11	<5	10	New York, N. Y	1.14	1.14	6	9	<5	5
Buffalo, N. Y	1.16	1.18	6	6	<5	<5	Norfolk, Va	1.12	1.20	6	9	<5	<5
Burlington, Vt	1.28	1.21	12	9	<5	10	Oklahoma City, Okla.	1.28	1.20	6	8	<5	<5
Charleston, S. C	1.28	1.29	8	10	10	5	Omaha, Nebr	1.10	1.05	5	6	10	5
Charleston, W. Va	1.22	1.19	4	8	<5	<5	Palmer, Alaska	1.10	1.08	4	7	<5	10
Charlotte, N. C	1.29	1.24	8	11	<5	5	Philadelphia, Pa	1.27	1.19	8	8	<5	5
Chicago, Ill	1.16	1.15	5	6	<5	<5	Phoenix, Ariz	1.20	1.05	1	3	<5	10
Cincinnati, Ohio	1.22	1.20	8	8	<5	<5	Pittsburgh, Pa	1.26	1.22	8	11	<5	5
Cleveland, Ohio	1.16	1.17	6	7	<5	<5	Portland, Me	1.16	1.15	10	11	20	15
Dallas, Texas	1.30	1.23	4	6	<5	<5	Portland, Oreg	1.15	1.12	6	10	15	25
Denver, Colo	0.96	1.09	6	6	<5	10	Providence, R. I	1.25	1.22	8	11	<5	10
Des Moines, Iowa	1.00	1.04	6	7	5	10	Sacramento, Calif	1.08	1.09	2	4	<5	<5
Detroit, Mich	1.20	1.17	5	7	<5	<5	Salt Lake City, Utah.	1.02	1.09	3	5	10	5
Grand Radids, Mich.	1.25	1.24	8	8	<5	5	San Francisco, Calif.	1.13	1.11	2	4	<5	5
Hartford, Conn	1.20	1.19	7	8	10	10	San Juan, P. R	1.07	1.15	2	4	<5	<5
Helena, Mont	1.00	1.07	4	6	5	10	Seattle, Wash	1.07	1.09	7	8	10	25
Honolulu, Hawaii	1.04	1.07	4	5	<5	15	Spokane, Wash	1.04	1.09	5	7	10	15
Idaho Falls, Idaho	1.07	1.07	5	5	<5	15	St. Louis, Mo	1.02	1.04	6	7	15	25
Indianapolis, Ind	1.24	1.22	6	6	<5	<5	Syracuse, N. Y	1.29	1.22	6	8	<5	10
Jackson, Miss	1.39	1.33	10	11	<5	<5	Tampa, Fla	1.26	1.28	5	5	25	60
Kansas City, Mo	1.02	1.07	6	8	<5	10	Trenton, N. J	1.22	1.22	6	8	<5	<5
Laramie, Wyo	1.08	1.06	5	5	<5	5	Washington, D. C	1.16	1.18	6	8	<5	<5
Las Vegas, Nev	1.06	1.05	2	2	<5	<5	Wichita, Kans	1.05	1.08	5	6	<5	<5
Little Rock, Ark	1.34	1.23	14	13	10	<5	Wilmington, Del	1.17	1.21	6	8	<5	5
Louisville, Ky	1.18	1.19	8	8	<5	<5							
Manchester, N. H	1.18	1.22	8	11	10	25							

Because this program was initiated in 1960 and sampling necessarily became operative in a staggered sequence, the averages shown represent all analyses performed to date. Average will normally be for the latest 12 month period after sampling began. For the February data, the averages include five to twelve analyses.

SECTION IV.—WATER

National Water Quality Network

Division of Water Supply and Pollution Control, Public Health Service

The National Water Quality Network was established under the provision of Section 4(c) of Public Law 660, which states "***The Surgeon General shall***collect and disseminate basic data***[relating] to water pollution and the prevention and control thereof."

This Network, operated in cooperation with State and local health agencies, was started in October 1957. At present, there are 75 sampling stations located on major waterways used for public water supply, propagation of fish and wildlife, recreational purposes, and for agricultural, industrial, and other uses. Some of these stations are on interstate, coastal, and international boundary waters, and waters on which activities of the Federal Government may have an impact. Ultimately, a total of 250 to 300 stations will be in operation. A few of the more recently established stations have not begun to report radioactivity.

Samples of water are examined for chemical, physical, and biological quality insofar as these relate to pollution. Samples for some determinations are taken weekly, others monthly, and for some continuous composite samples of 10 to 15 days are obtained.

Gross alpha and beta measurements are made on both suspended and dissolved solids in the raw surface water samples. The levels of radioactivity associated with dissolved solids provide a rough measure of levels which may be found in a treated water, where such water treatment removes substantially all of the suspended matter. Naturally occurring radioactive substances in the environment are the source of essentially all of the alpha activity. The contamination of the environment from manmade sources is the major contributor to the beta activity. It should be noted that with the cessation of weapons testing, beta activity in most raw waters is generally approaching a level attributable solely to natural beta activity. Natural beta activity can be two or three times the natural alpha activity based on the presence of the same nuclides. Some exceptions to this are seen, notably the data for the Columbia River and the Animas River.

While beta determinations for the first two years of the Network operation have been conducted on each sample weekly, the alpha determinations are reported generally on a composite sample of more than one week. Beginning with samples taken in January 1960, beta determinations were performed on composite samples obtained by combining two weekly samples. The alpha data will be reported on three-month composite samples, with one-quarter of the stations being covered each month. All the data reported in table 1 represent the average of all information available for the month indicated.

Strontium-90 data reported are the results

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

(Average concentrations in $\mu\mu$c/liter)

Station	Quarter ending December 31, 1960	January 1961					
		Beta activity			Alpha activity		
	Strontium-90	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River: Cedar Hill, N. Mex.		29	19	48	9	19	28
Apalachicola River; Chattahoochie, Fla.		0	5	5			
Arkansas River:							
Coolidge, Kans.		0	0	0	1	31	32
Ponca City, Okla.		8	0	8	0	0	0
Pendleton Ferry, Ark.	(1)	0	0	0	1	1	2
Chattahoochie River:							
Atlanta, Ga.	0.3	<1	2	2	0	0	0
Columbus, Ga.		0	0	0	0	0	0
Colorado River:							
Loma, Colo.		0	0	0	2	11	13
Page, Ariz.	0.4	4	28	32	<1	20	13
Hoover Dam, Ariz.-Nev.		0	4	4	0	9	9
Parker Dam, Ariz.-Calif.	1.2	0	0	0	0	12	12
Yuma, Ariz.		0	0	0	0	10	10
Columbia River:							
Pasco, Wash.		133	758	891	0	1	1
Bonneville Dam, Oreg.	0.5	66	258	324	0	1	
Clatskanie, Oreg.		24	142	166			
Delaware River:							
Martin's Creek, Pa.		0	0	0	0	0	0
Philadelphia, Pa.		0	0	0	1	<1	2
Escambia River: Century, Fla.	(1)	0	0	0	1	1	2
Great Lakes:							
Gary, Ind.		0	0	0	0	0	0
Duluth, Minn.		0	1	1	0	0	0
Detroit, Mich.		0	1	1	0	0	0
Buffalo, N. Y.		1	0	1	<1	1	2
Milwaukee, Wis.	0.2	0	0	0	0	<1	<1
Hudson River: Poughkeepsie, N. Y.	0.4	0	1	1	0	0	0
Illinois River; Peoria, Ill.	0.5	0	9	9	1	3	4
Kanawha River: Winfield Dam W. Va.	0.2	0	<1	<1			
Klamath River; Copco, Oreg.		0	2	2	0	<1	1
Little Miami River; Cincinnati, Ohio	(1)	0	1	1	1	1	2
Mississippi River;							
Red Wing, Minn.		0	4	4	0	2	2
Burlington, Iowa		0	0	0	1	1	2
E. St. Louis, Ill.		0	0	0	0	4	4
Cape Girardeau, Mo.		0	0	0	1	1	2
West Memphis, Ark.	1.0	0	12	12	1	1	2
Delta, La.		0	12	12	1	1	2
Missouri River:							
Williston, N. Dak.		0	2	2	0	7	7
Yankton, S. Dak.		0	0	0	0	5	5
Omaha, Nebr.		0	0	0	0	6	6
St. Joseph, Mo.	0.5	0	0	0	0	4	4
Kansas City, Kans.		0	4	4	0	4	4
St. Louis, Mo.		4	2	6	1	6	7
Ohio River:							
East Liverpool, Ohio		0	0	0	0	1	1
Wheeling, W. Va.	0.6						
Huntington, W. Va.	0.4	0	0	0	1	1	2
Evansville, Ind.	0.8	11	0	11	2	0	2
Cairo, Ill.		4	0	4	0	0	0
Potomac River:							
Williamsport, Md.		3	0	3	0	0	0
Great Falls, Md.		0	0	0	0	0	0
Red River, North: Grand Forks, N. Dak.		0	7	7	0	4	4
Red River, South:							
Denison, Tex.	0.7	0	0	0	0	2	2
Index, Ark.		0	5	5	2	2	4
Alexandria, La.		51	2	53	10	1	11
Rio Grande River:							
Alamosa, Colo.		4	9	13	0	2	2
El Paso, Tex.		0	0	0	1	0	1
Laredo, Tex.		0	0	0	0	2	2
Brownsville, Tex.		0	0	0			
Sabine River: Ruliff, Tex.		5	1	6	<1	<1	1
St. Clair River; Port Huron, Mich.		<1	0	<1	0	<1	<1
St. Lawrence River: Massena, N. Y.	0.6	0	<1	<1	0	1	1
St. Mary's River: Sault Ste. Marie, Mich.		0	1	1	0	0	0
Schuylkill River: Philadelphia, Pa.	(1)	0	0	0	0	1	1
Savannah River:							
Port Wentworth, Ga.	0.5	0	16	16			
North Augusta, S. C.		0	2	2	0	0	0
Snake River:							
Wawawai, Wash.		0	0	0	0	3	3
Weiser, Idaho	0.2	1	12	13	0	4	4
Susquehanna River:							
Sayre, Pa.		1	<1	1	0	<1	<1
Conowingo, Md.	0.4	0	0	0	0	<1	1
Tennessee River:							
Chattanooga, Tenn.	0.9	2	125	127	0	2	2
Bridgeport, Ala.		0	68	68	0	0	0
Yellowstone River; Sidney, Mont.		0	0	0	0	20	20

[1] Insufficient sample for analysis.

of determinations on composite samples for a three-month period ending in the month shown.

Additional information and data may be obtained from the following sources:

National Water Quality Network Annual Compilation of Data, PHS Publication. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price $1.50.

Report on National Water Quality Control Network, submitted by Dr. F. J. Weber, Chief, Division of Radiological Health, PHS, at the Joint Committee on Atomic Energy Hearings on Fallout from Nuclear Weapons Tests, Vol. 1, May 1959, pages 167-169.

Setter, L. R., Regnier, J. E., and Diephaus, A. "Radioactivity of Surface waters in the United States," Jour. AWWA *51,* 1377 (1955).

Straub, C. P., Setter, L. R., Goldin, S., and Hallbach, P. F., "Strontium-90 in Surface Waters," Jour. AWWA *52,* 756 (1956).

Setter, L. R., and Baker, S. L., "Radioactivity of Surface Waters in the United States," *Radiological Health Data,* Volume I, No. 7 (1960).

FIGURE 1—PUBLIC HEALTH SERVICE NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS

As of June 30, 1960

SECTION V.—OTHER DATA

External Gamma Activity

Radiation Surveillance Network,

Division of Radiological Health, Public Health Service

Portable survey instruments are available at stations of the Radiation Surveillance Network for recording levels of external gamma radiation. Measurements are made daily approximately three feet above the ground. These readings are not precise but are sufficiently accurate to illustrate any significant variations above background. The differences among the values shown in the following table are within the variance anticipated due to differences in normal background and in instrument response characteristics.

TABLE 1.—EXTERNAL GAMMA ACTIVITY, FEBRUARY 1961

Radiation Surveillance Network, Public Health dervice

Station location	Average (mr/hr)	Station location	Average (mr/hr)	Station location	Average (mr/hr)
Anchorage, Alaska	0.01	Indianapolis, Ind	0.01	Oklahoma City, Okla	0.01
Fairbanks, Alaska	[1]	Iowa City, Iowa	0.02	Ponca City, Okla	0.04
Juneau, Alaska	0.01	Topeka, Kan	0.02	Portland, Oreg	0.02
Phoenix, Ariz	0.02	New Orleans, La	0.01	Harrisburg, Pa	0.01
Little Rock, Ark	0.02	Baltimore, Md	0.02	Providence, R. I	0.02
Berkeley, Calif	0.01	Lawrence, Mass	0.02	Columbia, S. C	0.02
Los Angeles, Calif	[1]	Lansing, Mich	0.02	Edgemont, S. Dak	Inactivated
Denver, Colo	0.02	Minneapolis, Minn	0.01	Pierre, S. Dak	0.02
Hartford, Conn	0.01	Pascagoula, Miss	[1]	Austin, Tex	0.01
District of Columbia	0.02	Jefferson City, Mo	0.01	El Paso, Tex	0.02
Jacksonville, Fla	0.02	Helena, Mont	0.03	Salt Lake City, Utah	0.02
Atlanta, Ga	[1]	Trenton, N. J	[1]	Richmond, Va	0.01
Honolulu, Hawaii	0.02	Santa Fe, N. M	0.04	Seattle, Wash	0.02
Boise, Idaho	0.01	Albany, N. Y	0.02	Madison, Wis	0.01
Springfield, Ill	[1]	Gastonia, N. C	0.02	Cheyenne, Wyo	0.02

[1] No Data Received.

Cesium-137 Levels In Humans

Walter Reed Army Institute of Research, Washington, D.C. and

U.S. Army Medical Research Unit, Landstuhl, Germany

Despite the cessation of nuclear weapons testing in the fall of 1958, the United States Army Medical Service has maintained a surveillance of the fission product contamination in the human population. Two whole body counting facilities at the Walter Reed Army

Medical Center, Washington, D.C. and the Medical Research Unit, Landstuhl, Germany have been measuring the levels of cesium-137 in people. A description of each facility and previous data were summarized in *Radiological Health Data*, Volume II, Number 4.

This report presents the results from Germany for the period December 1960 through February 1961 and from Walter Reed for the first quarter of 1961. The Landstuhl data area listed by month in table 1. The Walter Reed data are listed by geographic area in tables 2 and 3.

TABLE 1.—ASSAYS PERFORMED AT THE U. S. ARMY MEDICAL RESEARCH UNIT, LANDSTUHL, GERMANY

Date	Subjects residing in—	Number of subjects	$\mu\mu$c Cs^{137}/gm K (average)
December 1960	West Germany	75	54
January 1961	do	165	54
February 1961	do	107	46

TABLE 2.—ASSAYS PERFORMED AT THE WALTER REED ARMY INSTITUTE OF RESEARCH, FIRST QUARTER 1961

Geographic area	Number of subjects	$\mu\mu$c Cs^{137}/gmzK (average)
Africa	1	35
Antarctica	1	50
Caribbean	4	37
Central America	1	27
Europe	32	52
Far East	28	30
Near East	2	49
Pacific Islands	1	26
United States	170	31

TABLE 3.—ASSAYS OF INDIVIDUALS RESIDING WITHIN THE UNITED STATES PERFORMED AT THE WALTER REED ARMY INSTITUTE OF RESEARCH, FIRST QUARTER 1961

State	Number of subjects	$\mu\mu$c Cs^{137}/gm K (average)
Alabama	2	24
Alaska	3	27
Arizona	1	18
California	8	23
Colorado	2	36
Connecticut	1	54
District of Columbia	11	52
Florida	2	35
Georgia	6	30
Hawaii	1	26
Illinois	4	27
Indiana	3	37
Iowa	3	33
Kansas	2	26
Kentucky	8	26
Louisiana	1	24
Maryland	8	28
Massachusetts	7	51
Michigan	7	25
Minnesota	7	21
Mississippi	2	24
Missouri	2	17
Nebraska	1	39
North Carolina	7	36
North Dakota	1	37
New Jersey	3	30
New York	13	36
Ohio	8	17
Oklahoma	4	32
Oregon	1	33
Pennsylvania	13	30
Rhode Island	1	35
South Carolina	1	15
Texas	6	29
Utah	1	37
Vermont	1	40
Virginia	13	32
Washington	2	40
West Virginia	3	27
Wisconsin	1	28

TABLE 4.—SUMMARY OF TABLES 1 AND 2—FIRST QUARTER 1961

Geographic area	Number of subjects	$\mu\mu$c Cs^{137}/gm K (average)	Percent MPC [1]
Africa	1	35	0.18
Antarctica	1	50	0.25
Caribbean	4	37	0.19
Central America	1	28	0.14
Europe	32	52	0.26
Far East	28	30	0.15
Near East	2	49	0.25
Pacific Island	1	26	0.13
West Germany	347	[2] 52	0.26
United States	170	31	0.16

[1] See *Radiological Health Data*, Volume II, Number 4, pages 193 and 194.
[2] Values represent determinations for December 1960 through February 1961.

Medical Survey of Rongelap People, Five and Six Years After Exposure To Fallout[1]

U.S. Atomic Energy Commission

Following the accidental exposure to fallout radiation of inhabitants of Rongelap Atoll in the Marshall Islands in March 1954, medical surveys of the Rongelap people have been made annually under the direction of the Brookhaven National Laboratory. The summary and conclusions of the report of the survey conducted five and six years after exposure follow. Several other agencies and organizations provided assistance in conducting the surveys, namely:

The Department of Public Health, Trust Territory of the Pacific Islands; Walter Reed Army Medical Center; South Nassau Communities Hospital, New York; Atomic Bomb Casualty Commission, Japan; Anderson Hospital, University of Texas; National Institutes of Health, Public Health Service; Naval Medical Research Institute; Memorial Hospital for Cancer and Allied Diseases, New York.

A list of previous reports is shown following the summary.

"*Summary and Conclusions*"

"Continuing annual medical surveys of the people of Rongelap Island were carried out in March 1959 and March 1960, 5 and 6 years after their accidental exposure to fallout. During the 1959 survey 76 exposed persons, including their children, and 166 unexposed Rongelap people, who served as a comparison population, were examined. In addition, groups of children at Utirik, Majuro, and Kwajalein Atolls were examined as controls for the growth and development studies on the exposed Rongelap children. The 1960 survey was brief, only the exposed people being examined.

"As a result of their exposure in 1954, many of the Rongelap people had experienced early symptoms related to the gastrointestinal tract and skin. Later they developed a significant depression of their peripheral blood elements commensurate with the calculated dose of gamma radiation (175 r to 64 people and 69 r to 18 people), and beta burns of the skin along with spotty epilation. In addition, radiochemical analyses of urine samples showed that they acquired a low level body burden of radionuclides. Certain other findings were possibly related to their radiation exposure, such as loss in weight of several pounds in most of the people during the first several months after exposure and suggestive evidence of slight lag in growth and development of the children based on studies of height, weight, and bone development (but inconclusive pending verification of exact ages of some of the children).

"In spite of the depression of hemopoiesis, no signs of radiation illness developed in the people related to such depressions, and no deaths occurred that could be related to their radiation exposure. No specific therapy was given. Recovery of the peripheral blood elements, particularly lymphocytes and platelets, was very slow over the ensuing years. The beta burns, which appeared about 2 weeks after exposure, were, for the most part, superficial in nature and healed in several weeks, with only a few lesions showing later persisting changes. Specific therapy was not necessary in most cases. The hair regrew normally, beginning at 3 months after exposure. The internally absorbed radionuclides caused no known acute effects and were excreted remarkably fast with barely detectable activity being found a year or two later. On return of the people to Rongelap Island the very low levels of radioactive contamination remaining there resulted in a rise in their body burdens of cesium-137, zinc-65, and strontium-90.

"The 5- and 6-year post-exposure surveys were aimed primarily at evaluating the general medical status of the people in relation to that of the unexposed comparison population, particularly in regard to any possible late developing effects of their exposure, their hematological status, and the influence of the slightly

[1] "Medical Survey of Rongelap People Five and Six Years After Exposure to Fallout" AEC report BNL-609 (T-179), September 1960. Available from the Office of Technical Services (OTS), U.S. Department of Commerce, Washington 25, D.C., $2.00.

contaminated environment on the assimilation, excretion, and body burden of radionuclides.

"*Medical histories* of the intervals between the examinations in 1959 and 1960 were, for the most part, uneventful and revealed no major epidemics of disease. Several deaths had occurred and new births were reported. In the exposed group, two deaths occurred and in the unexposed group, three. Two of the latter were due to influenza acquired during an epidemic on Kwajalein.

"The four deaths that have occurred in the exposed people since exposure represent a mortality rate of 8.1 per 1000 population, compared with 8.3 for the comparison population and 6.8 for the Marshall Islands as a whole. A review of the birth rate of the exposed group over the past 6 years seems to indicate no noticeable effect of their exposure on fertility. The 24 births represent a rate of 48 per 1000 population, compared with 37.3 for the Marshall Islands (1957). The 20 births over a 3-year period for the comparison population represent a rate of 62 per 1000 population. A somewhat greater incidence of miscarriages and stillbirths has been noted in the exposed women, but because of the paucity of vital statistics on the Marshallese and the small number of people involved, the data are not readily amendable to statistical analysis.

"*Physical examinations* showed the exposed and the unexposed people to be generally in a state of good health. No diseases were noted that could be directly related to radiation effects. The incidence of various disorders in both adults and children was about the same in the exposed and unexposed groups.

"In connection with growth and development studies, a project on the verification of accuracy of ages of the children has not been completed and, therefore, the suggestive evidence previously presented of possible lag in statural growth in the exposed children must await confirmation. It was noted, however, that in the 6-year chronological age group, three boys and one girl out of five boys and two girls in the exposed group exhibited significantly retarded skeletal maturation as judged by x-ray examination. The birth dates of these children seemed to be fairly well established.

"*A cardiovascular survey* of the adults showed no outstanding differences between the exposed and unexposed groups. The people appeared to have less hypertension on the whole than is noted in people in the continental United States.

"*An arthritis survey* showed no great differences between the exposed and the unexposed people, and about the same incidence as is seen in American populations.

"*An ophthalmological survey* showed no remarkable differences between the exposed and unexposed groups except possibly a slightly greater number of cases of pterygii, pingueculae, and corneal scars in the exposed group. It is not known whether this finding is of any significance in relation to their radiation exposure. Slit-lamp observations showed no opacities of the lens characteristic of radiation exposure. As a whole, visual and accommodation levels in the Marshallese appeared to be above the average in the U. S. population.

"*A dental survey* showed no significant differences in either caries rate or incidence of peridontal disease between exposed and unexposed groups. The poor oral hygiene generally observed in the Marshallese had its usual results, namely, high caries rate in teenage children, severe peridontal lesions in adults (heavy calculus and loss of alveolar bone), and edentulous mouths in the aged. Radiation exposure did not appear to have effected developing dentition in the exposed children.

"*Late effects of radiation.* Various parameters usually associated with aging were measured or estimated on a 0 to 4+ scale (skin looseness, elasticity, and senile changes; greying of the hair and balding; accomodation, visual acuity, and arcus senilis; hearing; cardiovascular changes including blood pressure and degrees of peripheral and retinal arteriosclerosis; neuromuscular function; and hand strength). Comparison of these measurements in exposed and unexposed individuals of the same age groups showed no apparent differences. A biological age score was calculated for individuals and groups by use of an average percentage score. Life shortening effects of radiation have not been apparent. As noted, the mortality rate was about the same in the exposed as in the unexposed people.

"The one case of cancer that developed in the exposed group occurred at 5 years after exposure, too soon, it is believed, to bear any

particular relation to radiation exposure. Leukemia surveys including physical findings, studies of white cell counts and types, alkaline phosphatase staining, and basophil counts of 4000 white cells showed no evidence of leukemia or leukemic tendency. One child in the irradiated group had 3% basophils but no other positive findings. The cardiovascular and arthritis surveys, as well as the general results of the physical examinations, have not shown any apparent increased incidence of degenerative diseases in the exposed people. No radiation-induced cataracts have been observed in any of the exposed people.

"*Genetic effects* have not been specifically studied because of the small number of people involved. No apparent radiation-induced genetic changes have been detected on routine physical examination in the first-generation children of exposed parents.

"*Hematological surveys* again showed considerable fluctuation in the year-to-year mean level of leukocytes in both the exposed and unexposed groups. The mean leukocyte level of the exposed group showed a marked decrease at the time of the 1960 survey (no unexposed people were examined). The reasons for these fluctuations are not apparent. At 5 years post exposure, exposed people still had mean platelet levels 10 to 15% below those of the unexposed group. However, lymphocyte levels appeared for the first time to equal those of the unexposed group. Mean erythrocyte levels were also slightly lower in the exposed people. These blood elements in the Ailingnae group also showed some slight depression below the unexposed levels but not quite so marked as seen in the Rongelap exposed group. A general anemic tendency was noted in all the Marshallese, both exposed and unexposed. Price-Jones curves, on the average, showed a slight microcytic tendency. Serum iron levels were generally normal. The fact that some of the blood elements in the exposed group have not yet returned to the levels in the unexposed group raises the possibility that a residual radiation effect on the bone marrow persists, but other, not immediately apparent, factors may be involved.

"*Studies of genetically inherited characteristics.* Blood grouping studies in the Marshallese showed a relatively high B gene frequency, a high N gene frequency, an extremely high R^1 gene frequency, and total absence of Kell and Diego factors. These characteristics differ from those of Polynesians and suggest relationship with Southeast Asians and Indonesians. Haptoglomin studies showed the frequency of the Hp^1 gene to be higher than in European populations thus far tested and consistent with populations living near the equator. The distribution of haptoglobin types showed the population to be relatively homogeneous. Transferrins in all sera were type CC, the common European type. ß-Aminoisobutyric acid urinary levels showed the Marshallese to be the highest excretors of acid of any population thus far reported. Levels in the exposed group were about the same as in the unexposed group, and no correlation was found with body burden levels of radionuclides; this indicates that there is probably no correlation with radiation exposure. Glucose-6-phosphate dehydrogenase of the red cells appeared to be deficient in the Marshallese. Considerable caution must be exercised in evaluating the results of these studies on genetically inherited characteristics because of the small number of samples tested. The data do seem to indicate relative homogeneity of the population and closest kinship with people of Southeast Asia. These data also may be useful as a base line should genetic changes appear in later generations, possibly related to radiation exposure.

"Results of other laboratory studies carried out during the 5-year survey included the following: Serum protein levels, as has been noted before, were generally on the high side of normal; the reason for this is not apparent. Complement fixation studies for parainfluenza 1, 2, and 3, respiratory syncitial, psittacosis, and Q fever showed antibodies to all groups of viruses except that for Asian influenza, which probably had not yet seriously involved the people of the Marshall Islands. The antibody titers appeared to be somewhat lower in the exposed people. Sodium levels in the urine and food indicated about the same consumption of NaCl as in Americans. The generally lower incidence of hypertension in the Marshallese might be related to the fact that the former native diet was probably lower in salt content than the present, more westernized diet. It will be interesting to see whether the incidence

of hypertension will later increase. Repeat studies of protein-bound iodine, total iodine, and butanol-extractable iodine of the sera showed levels lower than previously reported, and the previous higher readings are thought to be in error because of contaminated glassware, although some readings were still somewhat high. Four cases of glucosuria associated with elevated blood sugar were found in the unexposed population, which indicated a rather high incidence of diabetes. Serum assay for vitamin B_{12} showed generally high levels; the explanation was not apparent.

"*Radionuclide body burden evaluation* in the Marshallese people has been complicated by several things. The people were evacuated from their island soon after the accident and did not return until 3 years later. During the 5 years since the contaminating event, additional weapons tests held in the area have contributed to the fission products in the environment. Finally, since the diet includes a variety of imported foods, the people are not living in a "closed" environment, and therefore may not be rapidly approaching equilibrium with the environmental fission products, as might be expected under other circumstances.

"Body burdens of gamma-emitting fission products (such as Cs^{137} and Zn^{65}) were measured in a whole-body counter and checked by radiochemical analysis of urine specimens. Body burdens of Sr^{90} were estimated from urinary excretion as determined by radiochemical analyses. Both the external dose measurements on Rongelap Island and the levels of radioactive isotopes in the food on the island indicated that some increase in Cs^{137}, Zn^{65}, and Sr^{90} body burdens was to be expected when the people returned there in 1957. The Cs^{137} body burden in 1958 was about 0.68 μc about 60 times as great as in 1957, and the urinary Cs^{137} level rose by a factor of 140; the mean body burden for 1959 was 0.57μc. The mean body burden of Zn^{65} estimated from whole-body counting data was, in 1958, after the return to Rongelap, 0.36μc, 8 times as high as in 1957, and 0.44 μc in 1959. Thus, whereas the Cs^{137} levels appear to have reached a maximum and actually to have dropped in 1959, the Zn^{65} levels have shown a continued increase which is probably related to the long biological half-life of the latter. The Sr^{90} level in 1958 estimated from excretion data was 2mμc, about 20 times as high as in 1957 before the return to Rongelap. The estimated body burden in 1959 increased to 6.0 mμc, about 20% of the estimated ultimate equilibrium value. Little of the body burden of the exposed group is apparently due to their initial exposure, since at present there is little difference between the levels of the exposed and unexposed populations living on Rongelap Island. When these three isotopes have reached their estimated equilibrium values, the body burdens will still be of small significance in terms of radiation hazard.

"This study of the internal contamination of the Marshallese has provided information (1) on the movement of Cs^{137}, Zn^{65}, and Sr^{90} from the environment to man; (2) on the rate of equilibration of these isotopes with the environment; and (3) on the discrimination factors between food and man."

Reports on Previous Surveys

(1.) E. P. Cronkite, V. P. Bond and C. L. Dunham, ed., "Some Effects of Ionizing Radiation on Human Beings," AEC report TID-5358, U. S. Government Printing Office, July 1956. ($1.50)

(2.) E. P. Cronkite, et al, "Twelve-Month Post-Exposure Survey on Marshallese Exposed to Fallout Radiation," AEC report BNL-384 (T-71), August 1955. (Office of Technical Services, Department of Commerce $0.15)

(3.) R. A. Conard, et al, "Medical Survey of Marshallese Two Years After Exposure to Fallout Radiation," AEC report BNL-412 (T-80), March 1956. (OTS $0.20).

(4.) R. A. Conard, et al, "March 1957 Medical Survey of Rongelap and Utirik People Three Years After Exposure to Radioactive Fallout," AEC report BNL-501 (T-119), June 1958. (OTS $1.00).

(5.) R. A. Conard, et al, "Medical Survey of Rongelap People, March 1958; Four Years After Exposure to Fallout," AEC report BNL-534 (T-135), May 1959. (OTS $1.25).

RADIOLOGY IN THE UNITED STATES

Recently the American College of Radiology made available to its members "A Supplementary Report to 'The Practice of Radiology in the United States—Facts and Figures'." This was based upon a nation-wide survey of hospitals and radiologists by Doctors S. W. Donaldson and Carroll J. La Vielle to assess the use of x-rays, principally for diagnostic purposes. In 1951 Dr. S. W. Donaldson published his original paper, "The Practice of Radiology in the United States—Facts and Figures." This article has been the basis for a number of estimates of radiation exposures of the population since that time. In recent years data have been assembled and published relating to the number of x-ray examinations and exposures in a few scattered portions of the United States. However, there has been no nation-wide survey conducted to assemble such information, except for the continuing work by Donaldson and La Vielle in this field of interest.

The Division of Radiological Health has received permission from the American College of Radiology and, prior to his recent death, from Dr. Donaldson, to reproduce this supplementary report. We believe the basic information contained in this report, added to the other studies being conducted, will be useful in the long-term estimation of radiation exposures of the population.

A Supplementary Report To "The Practice of Radiology In The United States—Facts and Figures"

S. W. Donaldson, M.D. and Carroll J. La Vielle, M.D.—Ann Arbor, Michigan

"WHEN changes are occurring rapidly in industry, business or the practice of any profession it should be obvious that a periodic inventory must be made in order to keep abreast of the times. Approximately eight years ago information and statistical material was collected for preparation of a paper entitled "The Practice of Radiology in the United States—Facts and Figures." The reprints of the paper have had wide distribution. It was, at that time, an effort to assay the various financial and institutional aspects of the practice of a medical specialty. As stated in the body of the original paper the study was an outgrowth of a demand from recent trainees, seeking a location or position, for information pertaining to the distribution of radiologists and the opportunities available for entering into the practice of their specialty.

"The gathering of necessary information for proper functioning of the Professional Bureau has continued and through various spot checks and direct communications with well established radiologists who have found it necessary to take on assistants, it appears that the volume of patients seen in both private offices and institutional departments has doubled every eight years for the past twenty-four, following the nation-wide financial stress of the 1930's. The greatest upsurge in the utilization of diagnostic roentgenology came immediately following World War II, when those physicians who had not had the advantage of full time radiologic consultation were able to obtain it while in the service and demanded it from civilian radiologists when they returned to private practice. In 1951 it was stated that it was safe to assume that more radiological services were being rendered to the 42,000 persons population per radiologist than had been rendered to the 122,000 per radiologist in 1931. At an April 1958 U.S. Senate hearing the ratio of physicians to population was accepted at 1:750. Therefore, 1 radiologist to each 36 physicians would be approximately 1 radiologist to 27,000 population.

"A warning of this increase in the use of diagnostic x-ray and the subsequent requirements of more space and a greater investment in equipment and a need for more trained personnel was given in 1951, but the advice was not universally heeded. In an effort to provide aid to those institutions planning additional hospital beds and to those communities contemplating building a hospital, the American College of Radiology compiled and pub-

lished a "Planning Guide for Radiologic Installations," which has had a wide distribution. At the present time one is unable to predict whether or not the utilization of radiology for diagnosis and treatment is nearing a peak in volume of patients. If so, will future progress be confined to a refinement of methods of procedure in order to decrease the radiation exposure per individual or will new methods cause a greater usage of x-ray than is now foreseeable.

"At the beginning of the year 1958 there were in active practice in private offices and hospitals an estimated 4,500 radiologists who had been certified by the American Board of Radiology. In addition it was estimated that 600 more men were in training and assisting in rendering radiological services. Practically all qualified radiologists are now devoting full time to the specialty, although 849 physicians are listed in the 1956 American Medical Association Directory as maintaining a practice in which radiology receives special attention. The increase in the number of certified radiologists has more than kept pace with the growth in population and the increase in

of figures the number of radiologists in a state was subtracted from the total number of practicing physicians and the difference then divided by the number of radiologists in order to obtain the number of practicing physicians per radiologist.

"The most notable shifts in medical population have been from general practitioners to specialists and a definite loss in the number listed as 'special attention to a specialty.' The increase in the number of radiologists per 1,000 population since the 1950 census has been greater than in any previous period of the same number of years. According to United States Government census figures the center of population is constantly shifting westward. The tabulations of distribution of physicians by specialty and by states as shown in the 1956 American Medical Association Directory show a greater percentage increase in radiologists in the West than in the East with the greatest concentration in the state of California. The following table illustrates the increases and changes in the distribution of radiologists and physicians East and West of the Mississippi River.

SUMMARY OF DISTRIBUTION OF PHYSICIANS AND RADIOLOGISTS

		Radiologists			Physicians				
		Full spec.	Att. to spec.	Total	Gen. pract.	Full spec.	Physicians / Radiologists	Att. to spec.	Total
195	East	1,853	328	2,181	49,937	38,858	(57)	16,377	105,172
	West	788	101	889	22,613	15,933	(57)	6,662	45,208
1956	East	2,661	226	2,887	44,610	46,590	(36)	14,192	105,392
	West	1,279	54	1,333	20,106	20,524	(34)	6,283	46,913

medical practitioners. In 1950 the statistics showed one (1) radiologist to every fifty-seven (57) physicians as a national average. The present figures compiled from the 1956 American Medical Association Directory reveal 1 certified radiologist for every 36 physicians, that is, general practitioners and specialists who are rendering medical service to the general public. In the 1951 survey the number of practicing radiologists was not deducted from the total of general practitioners, specialists and those interested in a specialty as in some communities the practicing radiologists had many self referrals. In our new compilation

"The number of hospital beds in this country has definitely increased in the last decade and many communities without hospitals ten years ago now have facilities of varying size depending upon the money raising ability of the community. In such areas radiologists have become established either upon a full or part time basis. In addition to the general public, radiology has expanded in the governmental institutions, local, state and federal so that those radiologists rendering radiological service in the armed service and the Veterans Administration must be considered as a factor in the health and medical problems of the

general population as the shift from civilian practitioners to government medical personnel and back to civilian physicians is constantly occurring for some segment of the population. However, the socio-economic problem of the majority of radiologists is connected with the hospital and private office care of the general public. Occasional spot checks during the past several years have shown that the same general pattern has remained but with some variations from the report of 1951. The ratio of examinations to patients has increased slightly from 1.25 examinations per radiographic patient to 1.33 per patient. The number of patients having one or more diagnostic x-ray procedures after admission to a general hospital has increased from the average of 42% to 47%. Previously it had been considered that 20% of all procedures done by a radiologist were for therapy or were treatments. Our recent survey which includes approximately 500,000 patients shows that less than 15% of the procedures on these patients were therapy treatments. In order to obtain a cross section viewpoint questionnaires were sent to radiologists in a number of states and replies received from Massachusetts, Pennsylvania, Indiana, Illinois, Michigan, New York, Florida, Tennessee, California, Oklahoma, Minnesota and New Jersey. Two large teaching centers and three private offices were included.

"Fewer radiologists are in solo practice today than there were a few years ago. Even though there are still circuit riders covering several small hospitals and many hospitals in fringe areas of large cities receive part time service the major portion of hospital radiology is practiced in the larger institutions by two or more radiologists.

"A finding in the information furnished to the Professional Bureau by those institutions seeking a radiologist has been that the ratio between in-patient and out-patient examinations has shown an increase in out-patients in the midwest, western and southern parts of the country. This has been evident in that the number of examinations per department each year has been far in excess of the number of examinations expected for a hospital of a given bed capacity. Until a few years ago it was assumed that the in-patient and out-patient radiographic patients were about equal in number or the excess was generally in-patients but our latest investigation shows that the out-patient radiographic studies in most institutions now constitute a majority. All of these factors point out that smaller communities and fewer referring physicians are now able to support a radiologist.

"The formula presented in the previous paper that the personnel requirements for efficient functioning of a department of radiology were 5.6 patients per person personnel per day now appears to be 5.3. There has been an increase in paper work due to an increase in the number of subscribers to prepayment insurance plans. Microfilming and increased numbers of special examinations which monopolize rooms and technicians, more films per examination and other things not mentioned, require additional clerical and technical personnel. Film consumption has risen from approximately 2.5 films per examination to 3 and equipment value has practically doubled as new equipment for more specialized examinations is now required.

"The revenue per examination has increased within the past few years but is not uniform throughout the nation as the fees vary from the high in metropolitan areas to the low in low income communities. As a whole the fees for the various diagnostic procedures are relatively uniform and except for the isolated instances mentioned, generally fall in the median fee category. The average income per in-patient varies greatly according to the in-patient census of Blue Cross-Blue Shield subscribers and whether or not radiology is a benefit under Blue Cross. Some areas throughout the country have a high percentage of prepayment insurance plan subscriber admissions while hospitals in other communities have comparatively few. We have been unable to obtain a sufficient number of accurate statistics to enable us to predict the anticipated revenue to the Department of Radiology from each hospital bed per year. However, we have been able to show that the average revenue from each diagnostic in-patient is greater than the average revenue from the diagnostic out-patients. The total revenue per radiographic patient (in-patient and out-patient combined) will at the present time probably average

$15.00 or slightly less in those areas with a median fee schedule.

"Even with the increase in personnel, the increase in film consumption and other items of expense, the ratio of salaries to film and chemical cost remains the same. The ratio is 3 to 2 or, that is, it takes $33.00 in salaries (exclusive of medical personnel) to use $22.00 cost in films, chemicals and contrast media, as well as other expendable supplies.

"A noticeable shift in type of radiographic examinations has been in the Genito-Urinary field. The recent survey shows a wide variation in the different departments in the frequency of requests for intravenous pyelograms in comparison with requests for a retrograde examination. Some show as many as fifty intravenous examinations to one retrograde but the overall average is four to one.

"The figures for chest examinations and gastro-intestinal studies remain practically the same or approximately one-third of all radiographic examinations are procedures involving the chest and one-half of all radiographic examinations are made up of the chests and gastro-intestinal studies including the gall bladder. Previous to this supplementary paper it had been determined that 10% of all patients admitted to a general hospital have an x-ray examination of the gastro-intestinal tract and that 10% of all patients examined in a Department of Radiology have an examination of the stomach. This means that more than 10% of all diagnostic patients have an examination by fluoroscopy. Of each 30 gastro-intestinal examination patients 18 are over 45 years of age and 12 below 45. Except for progress or follow-up examinations very few requests are received in the larger departments for an examination of the stomach, colon or gall bladder alone and this shift from a single anatomical part examination to a study of the complete gastro-intestinal tract including the gall bladder has occurred within the past ten years.

"In the previous study from information collected in 1949 and 1950 it was determined that the average radiologist rendered consultation service for 20 patients per day. This average has now apparently increased and the information is based on figures given in the recent survey and from correspondence to the Professional Bureau requesting an assistant or associate. An increase of four patients a day per radiologist from 1950 to 1958 would place the average at 7,000 patients per year and deducting 15% for therapy or treatments would leave 5,950 radiographic patients, with 1.3 examinations per patient, who would account for 7,735 examinations per radiologist per year. The 1956 Directory of the American Medical Association shows 4,220 radiologists, full and part time and since that directory was published the American Board of Radiology has certified between 450 and 500 recent trainees who combined with some non-certified radiologists will raise the figure (with allowance for deaths and retirement) to almost 5,000 active practicing radiologists. Since its beginning the American Board of Radiology has certified 5,117 radiologists. In addition there are 200-300 third and fourth year residents who perform patient services equaling some radiologists. The 5,300 clinical radiologists rendering service for an average of as many as 7,000 radiographic examinations per year would make a total of 37,100,000 radiographic examinations by radiologists and their assistants per year. This number of examinations using an average of 3 films per examination would account for 111,300,000 films or exposures per year. If one desires to carry the radiation exposures further, then it is estimated that 20,000,000 radiographic examinations are made by non-radiologists and 11,000,000 by lay laboratories, chiropractors and osteopaths. Dentists account for 180,000,000 dental films or an equal number of dental exposures.

"As a matter of substantiation of the mathematical calculations the 1956 Directory of the American Medical Association shows that 347 non-federal and Veterans Administration hospitals and 16 Federal hospitals, namely one U.S. Air Force, four U.S. Army, six Navy, four U.S. Public Health Service and one Department of Health, Education and Welfare, are approved for residency or Fellowship training in Radiology. The Federal operated hospitals reported 749,944 x-ray examinations and these combined with the 11,079,987 examinations reported by the non-federal and V. A. hospitals give a grand total of 11,829,931 x-ray examinations in the 363 residency ap-

proved departments. The number of deep x-ray therapy treatments was 1,663,427 while superficial treatments and radium treatments were reported as 144,428 and 53,121 respectively. The treatments reported under the heading of radium probably represent a fair proportion of intracavitary cobalt 60. The percentage of high voltage therapy treatments in this group is higher than the average but could be expected as many of these larger hospitals are affiliated with a teaching center and have a therapy department which would attract therapy patients away from the general practitioner radiologist doing his own treatments.

"In 1956 the American Hospital Association reported a summary of hospitals and (beds) as 5,506 general hospitals (696,978), Tuberculosis 342 (76,380), Maternity 72 (3,108), EEN&T 48 (2,154), Psychiatric 569 (762,294), Orthopedic 81 (6,567), Contagious 12 (1,397), Chronic and Convalescent 207 (41,168) and 74 hospitals in miscellaneous categories, (10,966). All of the general hospitals of 50 beds or more have some x-ray equipment and most of the smaller hospitals with equipment usually receive service from a radiologist under the general term of rural radiology. It is estimated that the 363 residency approved departments will use the services of approximately one-third of the certified radiologists (1400) and all of the residents in radiology, as well as the radiation therapists. There are 152 physicians certified in therapeutic radiology only and most of these are affiliated with large teaching centers. With the assistance of residents the diagnostic work per radiologist each year should be greater than that of the radiologist without residents or 8,000 examinations per year for a total of 12,000,000 examinations. The remainder of the nation's 6,603 hospitals with x-ray equipment must therefore depend upon the remaining two-thirds of full time and part time radiologists for radiological service. The general hospitals with 696,978 beds admitting on the average 35 patients per bed per year will admit 23,394,430 patients and with the average of 45% of all patients having an x-ray examination after admission one can predict 10,530,000 x-ray examinations. We have shown the out-patient to in-patient ratio one plus to one but even though the total number of examinations is fewer for the out-patients we can anticipate more than 10 million additional examinations from the out-patients examined in the radiology departments of the remaining general hospitals, and the special hospitals such as tuberculosis, childrens, orthopedic and others of that group. The psychiatric hospitals with 762,294 beds take the majority of the 910,714 beds of the entire group.

"The number of therapy patients and therapy treatments has no relationship to the bed capacity of hospitals owning and operating therapy equipment. Tabulation of a number of 100-300 bed and larger hospitals showed definitely that there are many factors involved in the referral of therapy patients to one hospital instead of another of similar size and it was impossible to draw any conclusions as to percentage of therapy patients in relation to those for diagnostic procedures. In the 363 hospitals approved for radiological training the percentage of treatment patients as related to total examinations was about 15%. In the 100-250 bed hospitals in towns of 25,000-50,000 the percentage was slightly above 10%. These percentage figures are average for many hospitals and patients and cannot be applied to any one group of hospitals or area in this country.

"It is a well established fact that approximately 20% of all radiographic examinations are for the gastro-intestinal tract and usually involve two or more fluoroscopic procedures, namely the stomach and the colon. Twenty percent or one-fifth of the 37,100,000 examinations listed above would be 7,700,000 plus and with two fluoroscopic seances, either on the same day or on different days and in addition the fluoroscopic observations involving examinations of the heart, uterus and Fallopian tubes, chest, fracture reductions and other procedures entailing use of the fluoroscope one can easily account for 15,000,000 fluoroscopic examinations by radiologists each year. In addition to these examinations one must consider the photofluorographic hospital admission chest films and the nationwide chest surveys by mobile truck units conducted by state and local health departments and tuberculosis control agencies. All hospitals are not equipped for miniature film screening exami-

nations but some states report as many as 1,000,000 such examinations per year in combined hospital admissions and the traveling mobile truck units.

"Some interesting odds and ends of information gleaned from the records of the Professional Bureau of the American College of Radiology and the various surveys can be added to this supplement. In our most recent survey with questionnaires from eight geographic locations involving 413,456 patients the statistics were sufficiently accurate for use in determining that 171,691 radiographic patients produce 221,921 radiographic examinations or 1.33 per patient. We were also able to show the following percentages of the total examinations: Head—5.7%; Bone and Joint—31%; Gastro-intestinal including the gall bladder—20.7%; G.U.—4.7% and of the genito-urinary examinations—2.6% of all examinations were for an intravenous pyelogram and .7% for a retrograde or a total of 3.3% of all radiographic examinations were classified as a kidney with contrast study. The chest examinations, exclusive of miniature film were 30.7%.

"Suggestions pertaining to construction of room size, film filing space, equipment and supplies can be outlined in the following manner. The most efficient radiographic room size is apparently 224 sq. ft., usually 14 x 16 feet. Such a room size allows 4 feet 3 inches from the center of the radiographic table to the wall or sufficient room for passage of a stretcher. It was also found that 6 feet 3 inches from the center of the table to the control booth was the best location for the table. Time and effort studies were made with technicians wearing Pedometers. The numbers on the face of the instrument were taken as arbitrary figures and not as miles walked as the Pedometers were worn on the belt and activities other than walking affected the movement of the hand on the face of the dial. If the film pass box is from a room of the above size directly into the dark room a Pedometer worn by a technician should read 4 or 4 plus per day. If the technician is required to develop films, escort patients from the waiting room to the examining room and office, etc., the reading may be as high as 6 per day. Larger rooms than the above may show a reading of as high as 5 per day with the technician handling a similar number of patients as examined in the 14 x 16 foot room. We found that fatigue began at a reading of 4 and after that technical efficiency lowered and errors increased.

"Film filing is usually in Kraft paper film filing envelopes. If each single examination is filed the space required can be measured in units with each unit containing the average of four films and one envelope. If previous and current examinations are filed together in the same envelope the average thickness of each unit becomes greater. If the units vary from 4 to 10 films per envelope 120 units can be stored in each linear foot of shelf space. Film filing space must allow for aisles, film racks and handling space. One linear foot of 14½ x 17½ filing envelopes occupies 2.3 cubic feet. 100,000 x-ray films in filing envelopes will occupy 2,500 cubic feet of space but the same number of film on microfilm will occupy only 10 cubic feet of space. Microfilming is usually done after films are removed from the current files and mirofilms on rolls are referred to 5%-6% of requests for review of inactive films the first year, second year 2% and the third year a fraction of 1%. Microfilming before interpretation assures the greatest number of radiographs of cases being in the microfilm files.

"In other time and patient control studies it was found that the ratio of orderly transported patients for a department of radiology in a general hospial was usually three wheel chair and walk patients to one stretcher case. The average patient load of the average technician was found to be 20-24 patients per day. In larger departments with many technicians and some assigned to special study cases the average daily load will remain about the same. A typist of average or better speed can transcribe 10 Dictaphone cylinders or 6 belts during an eight hour day if the average dictation is 18-20 reports per belt. The transcribing time per belt is usually one hour and fifteen minutes. One cassette per patient per day was found to be the minimum number to have available for prompt handling of patients, i.e. 30 patients per day would require a total of 30 cassettes of various sizes and in good condition. Additional cassettes above this minimum will insure an increase in efficiency and

provide spares in the event of damage to cassettes or screens.

"In addition it was found that 1-1½ lbs. of fresh linen per patient per day was the average use in a hospital x-ray department. This includes sheets, pillow cases, towels, patient gowns, personnel uniforms and physicians' coats. A general hospital requires 17-18 lbs. of fresh linen per bed patient per day and the average life of a sheet or patient gown is 80 washings. 12 x-ray patient gowns weigh 8 lbs., 12 sheets 72 x 108 inches weigh 22 lbs. and 12 pillow cases 4 lbs.

"Using a relative value fee schedule for both diagnosis and for therapy an attempt was made to determine the comparative time spent as necessary to earn X dollars in therapy as it does to earn an equal amount in diagnosis. No conclusions could be made as more individuals are involved in a diagnostic procedure than in a treatment and the incomes of various places show a wide variance as related to paient load. However, it was found that with 10%-15% therapy treatments 85% of the total income was from diagnostic patients and 95% of the total costs (exclusive of medical personnel) are diagnostic costs.

"Again from the files of the Professional Bureau we find that requests for radiation therapists are few and infrequent. Most therapists are secured by direct contact with teaching centers offering complete training in therapeutic radiology. Practically all of the requests within the past year or two have been for men trained in diagnosis, therapy and isotopes. In our studies and correspondence we have been unable to detect any trend toward dividing radiology into two separate departments, namely—diagnostic and therapeutic. Such divisions do exist in the larger centers but in practically all cases the department of radiology is under one radiologist as director.

"In conclusion we hope that these statistical studies will be informative to radiologists, recent trainees and those who have been in practice for years, and in addition stimulate an interest in the value of statistical information as it pertains to the economic aspects of the practice of radiology.

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The United States Atomic Energy Commission is providing data on environmental levels of radioactivity in the vicinity of major Commission installations to the Public Health Service on a quarterly basis. The data are from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Radiological Health Data, Volume I, Numbers 8 and 9; and Volume II, Numbers 1 through 6 contain summaries for 17 installations. Summaries follow for Argonne National Laboratory, Oak Ridge National Laboratory and the Paducah Gaseous Diffusion Plant for the fourth quarter of 1960.

Argonne National Laboratory

University of Chicago
Lemont, Illinois

—Issued March 16, 1961

Environmental levels of radioactivity at Argonne National Laboratory (ANL) for 1959 and first and second quarters of 1960 were reported in *Radiological Health Data,* Volume I, Number 9 and Volume II, Number 4. The following report presents a summary of the data for the third and fourth quarters of 1960.

The environmental levels of radioactivity were determined by measuring the concentrations of radioactivity in naturally occurring materials collected at the ANL site and from as far away as one hundred miles. Since air and water are the most probable media for disseminating radioactivity, the environmental monitoring program at ANL has concentrated on these materials. The air and water sampling locations discussed in this report are shown in figures 1 and 2. Other materials, such as plants, soil, and river bottom sediment, and water from locations not shown on the map are analyzed also. The results of these analyses are not included here since they are not pertinent to the evaluation of ANL's contribution to the environmental radioactivity. All the data from the radioactivity monitoring program are given in annual reports issued by ANL.

Air Monitoring

Figure 1 is a map of the ANL site which has been divided into 1,000 foot squares by a series of grid lines. Sampling points at the site are identified by specifying the square in which they are located; for example, the Sawmill Creek sampling locations are in squares 13 L and 7 M. Sampling locations off the site (figure 2) are identified by giving geographical locations.

Samples are first analyzed for their total alpha and beta particle radioactivity. These analyses provide a rapid means of assessing the general radioactivity levels of the samples and indicate whether samples contain above-normal amounts of radioactivity. Some of these samples are then analyzed for the specific elements and nuclides that are likely to be responsible for the total alpha and beta activities observed.

The hazard due to a given concentration of a radioactive isotope is assessed by comparison with the maximum permissible concentration (MPC) recommended for that isotope by the National Committee on Radiation Protection and Measurements (NCRP). For populations in the vicinity of a nuclear energy installation the applicable maximum permissible concentrations are one-tenth of the occupational MPC's given in National Bureau of Standards Handbook Number 69. These lower MPC's are used throughout this report.

Air was sampled by drawing it through the filter paper at a known rate and analyzed by measuring the radioactivity in the particles collected on the paper. Samples were collected continuously at five locations at the Argonne site and at four off-site locations near Aurora, Hinsdale, Joliet, and Tinley Park. The filter papers were changed at weekly intervals. Quarterly averages of the data are tabulated below.

TABLE 1.—RADIOACTIVITY IN AIR FILTER SAMPLES

[Average concentrations in $\mu\mu c/m^3$]

Period (1960)	Location	Number of samples	Alpha	Beta
Third quarter	On-site	68	0.008	0.09
	Off-site	50	0.007	0.09
Fourth quarter	On-site	67	0.007	0.06
	Off-site	40	0.008	0.05

The data in table 1 were obtained by measuring samples three days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron products. This activity, normally present in the air and in considerably larger amounts than the activities expected from fallout or from ANL, disappears within three days by radioactive decay.

FIGURE 1.—SAMPLING LOCATIONS, ARGONNE NATIONAL LABORATORY

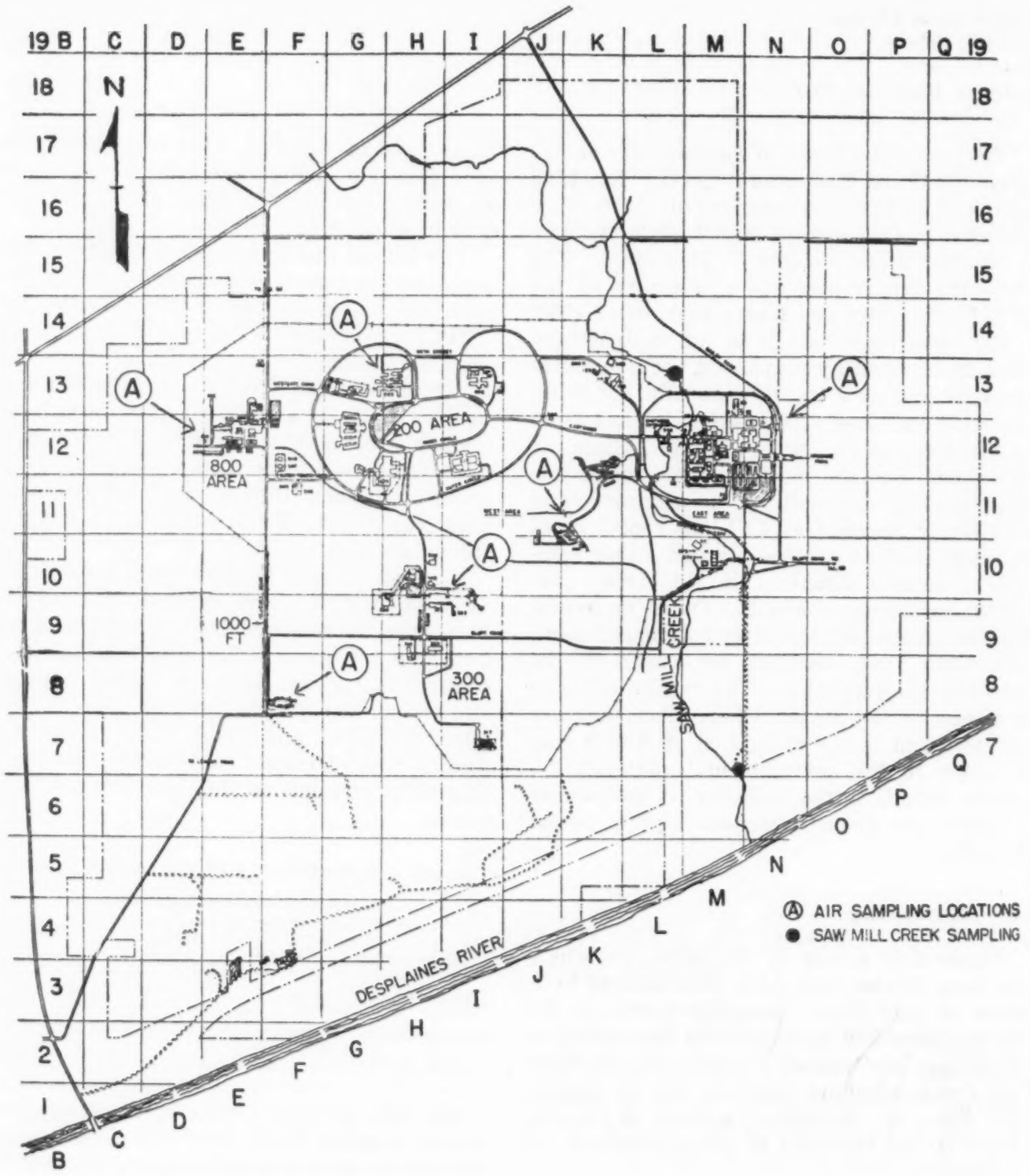
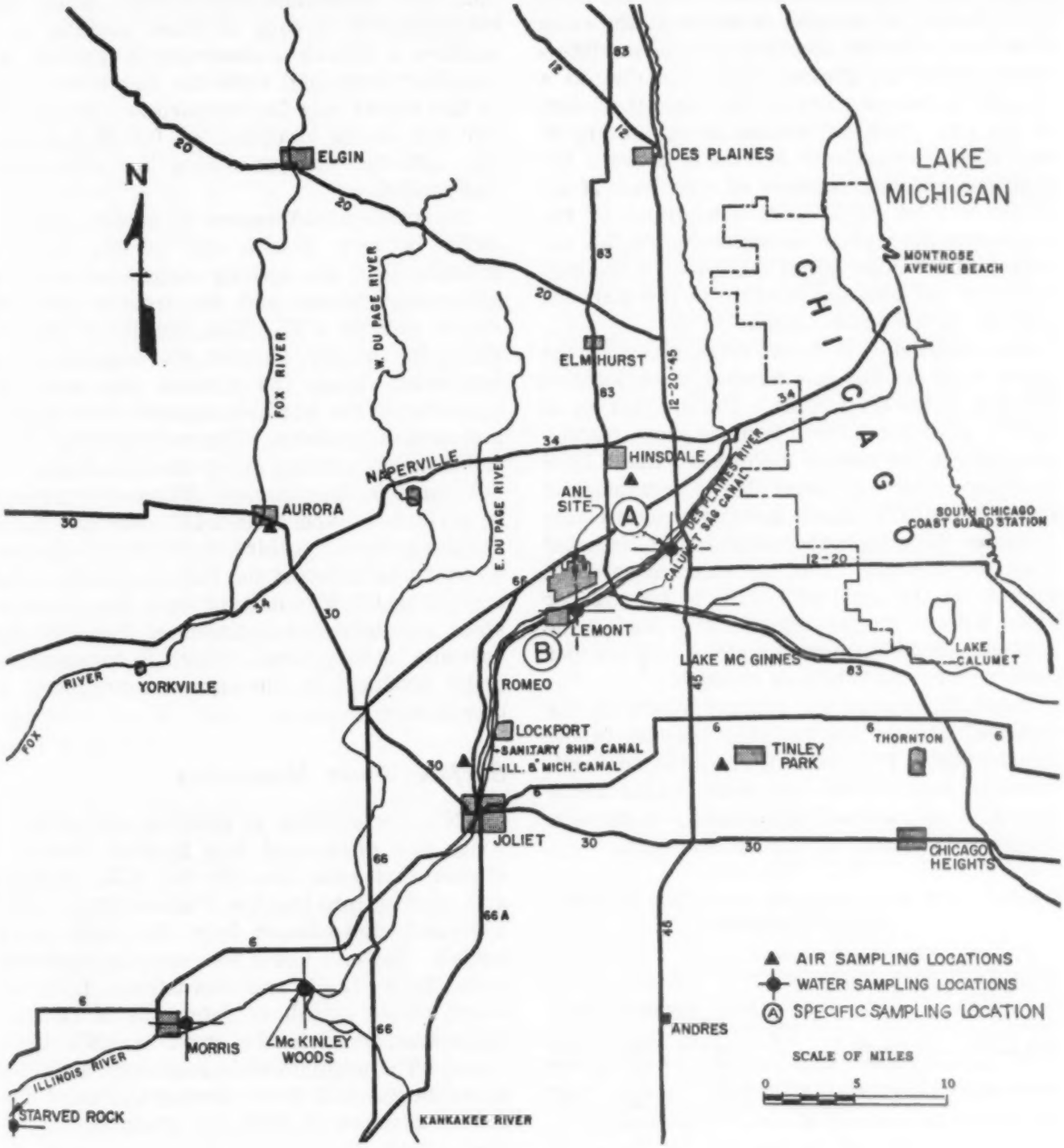

19 B C D E F G H I J K L M N O P Q 19
18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
N
A
800 AREA
200 AREA
300 AREA
1000 FT
SAW MILL CREEK
DESPLAINES RIVER
B C D E F G H I J K L M N O P Q
A AIR SAMPLING LOCATIONS
SAW MILL CREEK SAMPLING

FIGURE 2.—OFF-SITE SAMPLING LOCATIONS, ARGONNE NATIONAL LABORATORY



Within the sample collection and analytical error of 10 to 20 percent, the averages and ranges were the same both on and off the ANL site. Individual samples collected at the same time from different locations may show differences somewhat greater than this due to a variety of factors, such as the amount of dust in the air. Such differences become unimportant when comparisons are made between the averages of large numbers of samples. If activity used at ANL were discharged to the environment, higher activities would be expected on the site. Since this was not the case ANL did not add significantly to the airborne activity of the environment.

The alpha and beta activities given in the above table are due to a number of radioactive isotopes in the air sample. The application of MPC's to such mixtures is much more restrictive than in the case of a single nuclide. NBS Handbook No. 69 (page 94) recommends a series of MPC's which become progressively larger as the more toxic nuclides are eliminated from the mixture. For the samples collected near ANL, the applicable MPC is 100 μμc per cubic meter. The average activity during the last half of 1960, approximately 0.08 μμc per cubic meter, was 0.08% of the MPC.

Table 2 presents the concentrations of the principal gamma ray emitting nuclides in the air samples. This table gives additional evidence to support the conclusion stated above that ANL did not add significantly to the airborne radioactivity of the environment.

TABLE 2.—SPECIFIC NUCLIDE ACTIVITY IN AIR FILTER SAMPLES

[Average concentrations in $\mu\mu c/m^3$]

Period (1960)	Location	Ce^{144}	Ru^{106}-Rh^{106}	Cs^{137}
Third quarter	On-site	0.023	0.049	0.013
	Off-site	0.027	0.055	0.016
Fourth quarter	On-site	0.010	0.069	0.006
	Off-site	0.009	0.059	0.006

The above results were obtained by combining and counting as one sample all of the filter papers obtained each month from each location. The results given for the ruthenium-rhodium pair of nuclides were obtained from the counting rate of gamma rays with energies in the neighborhood of 0.5 Mev. The three principal nuclides in the air samples that emit such gamma rays are beryllium-7, rhodium-102, and ruthenium-rodium-106. Since the concentration of each of these nuclides in a mixture is difficult to determine by gamma ray counting alone, and since the results are used in this report only for comparison between off-site and on-site locations, the 0.5 Mev gamma ray activity was calculated as ruthenium-rodium-106.

The random differences in gamma ray activity between on-site and off-site samples indicate that the activity originated from a widespread source and not from a localized source such as ANL. The identity of the nuclides in the air samples also supports this conclusion, since the gamma ray activities were due to the nuclides expected from fallout and natural activity. The radioactivity from ANL should contain other nuclides that were not found in the samples. The concentrations of cerium-144 and cesium-137 decrease fairly regularly from the third to the fourth quarter as would be expected for fallout activity. The activity at 0.5 Mev did not show this decrease since a substantial fraction of this activity was due to beryllium-7, which is continuously being produced in the upper atmosphere by cosmic rays.

Surface Water Monitoring

ANL waste water is analyzed for radioactivity and discharged into Sawmill Creek, a stream that runs through the ANL grounds and empties into the Des Plaines River about 500 yards downstream from the waste water outfall. Sawmill Creek was sampled upstream from the ANL site and downstream from the waste water outfall to determine if radioactivity was added to the creek in ANL waste water. The uranium and gross alpha activities found in Sawmill Creek during the third and fourth quarters of 1960 are given in the following table.

Upstream from the ANL site the alpha activity was primarily due to naturally-occurring radionuclides. The increase in alpha activity below the waste water discharge was evidently due to radioactive material added to the stream by ANL waste water. Comparison of the total alpha activity with the uranium concentrations

TABLE 3.—URANIUM AND GROSS ALPHA ACTIVITY IN SAWMILL CREEK WATER

[Average concentrations in μμc/liter]

Period (1960)	Location (see fig. 1)	Uranium		Gross alpha	
		Number of samples	Activity	Number of samples	Activity
Third quarter	13 L	13	0.9	13	1.6
	7 M	21	9.2	37	8.5
Fourth quarter	13 L	11	0.9	13	1.4
	7 M	15	6.7	36	7.5

indicates that the alpha activity added to the creek in waste water from ANL was almost entirely due to the uranium.

Since the normal creek water is diluted approximately in half by waste water, the amount of uranium naturally present in the creek below the outfall was about 0.5 μμc/liter, one half of the uranium concentration above the site. Therefore, the average uranium concentration added to the creek by waste water during last half of 1960 was approximately 7.6 μμc/liter, or 0.04 percent of the MPC for populations (1/10 of the occupational MPC). Small amounts of plutonium and thorium originating in ANL waste water were also found in Sawmill Creek below the outfall. The alpha activities due to these elements are summarized in table 4.

TABLE 4.—PLUTONIUM AND THORIUM IN SAWMILL CREEK WATER—SECOND HALF 1960

[Average concentrations in μμc/liter]

Location (see fig. 1)	Number of samples	Plutonium	Thorium
Above-site (13 L)	8	<0.05	<0.05
Below-outfall (7 M)	24	0.14	0.16

The averages in table 4 were calculated assuming a concentration of 0.025 μμc/liter (one-half of the minimum detectable amount) in those samples containing less than 0.05 μμc/liter. All above-site samples and about one-third of the below-site samples contained less than 0.05 μμc/liter.

The presence of plutonium and thorium below the outfall was due to the waste water from ANL. The average concentrations of plutonium added to the creek in Argonne waste water amounted to approximately 0.003 percent of the population MPC. For thorium the corresponding percentage of the MPC was 0.008 percent. Radium 226 and other important alpha emitting nuclides were present only in normal concentrations in the creek.

The gross beta activity found in Sawmill Creek water during the third and fourth quarter of 1960 are tabulated below.

TABLE 5.—GROSS BETA ACTIVITY IN SAWMILL CREEK WATER

[Average concentrations in μμc/liter]

Period (1960)	Location (see fig. 1)	Number of samples	Activity
Third quarter	13 L	13	5.6
	7 M	17	40.8
Fourth quarter	13 L	12	5.9
	7 M	36	31.8

Several specific beta emitting nuclides have been detected in the creek as a result of their presence in ANL waste water. The concentrations of the most important of these nuclides are summarized in table 6.

TABLE 6.—SPECIFIC NUCLIDE ACTIVITY IN SAWMILL CREEK WATER—SECOND HALF 1960

[Average concentrations in μμc/liter]

Nuclide	Location (see fig. 1)	Number of samples	Activity
Sr^{90}	13 L	8	0.6
	7 M	24	9.5
Cs^{137}	13 L	8	0.4
	7 M	23	10.2
Co^{58}	13 L	4	<3
	7 M	20	346
Co^{60}	13 L	4	<3
	7 M	20	17

The results indicate that all the cobalt-58 and cobalt-60 and the bulk of the strontium-90 and cesium-137 in the river water below the outfall originated in ANL waste water. The only nuclide present in significant concentrations relative to the MPC was strontium-90. However, 80 percent of the strontium-90 occurred in one sample collected on December 9. Excluding this sample, the average strontium-90 concentration was only 1.9 μμc/liter (1.9 percent of the population MPC). Analyses for other fission products also were made, but they were either absent or present so infrequently and in such small concentrations that they con-

tributed negligible amounts of beta activity to the creek.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two streams is important. The Des Plaines River was sampled above and below the mouth of Sawmill Creek to determine if the radioactivity in Sawmill Creek had any effect on the activity in the river. The uranium and the gross alpha and beta found in the Des Plaines River during the third and fourth quarters are given in the following table.

TABLE 7.—GROSS ALPHA, BETA AND URANIUM ACTIVITIES IN DES PLAINES RIVER WATER

[Average concentrations in μμc/liter]

Period (1960)	Location (See fig. 2)	Number of samples	Alpha	Beta	Uranium
Third quarter	A	13	2.3	8.3	1.5
	B	13	2.1	8.7	1.6
Fourth quarter	A	10	2.5	10.2	1.5
	B	11	2.3	9.4	1.5

The alpha, beta, and uranium activities are in the range normally found in Des Plaines River water when fallout activity is low. There was no consistent or significant difference in activity between samples collected from the two locations. Additional water samples were obtained during July, September, and November from the Des Plaines River near Highway 34, upstream from Sawmill Creek, and near Romeo, downstream from Sawmill Creek. The alpha activities vary from 2.0 to 3.8 μμc/liter in the upstream samples and from 1.3 to 2.6 μμc/liter in the downstream samples.

The beta activities vary from 6.0 to 7.0 μμc/liter upstream to from 7.7 to 8.1 μμc/liter downstream. These activities are very similar to those found at locations A and B. The activities in the Des Plaines River were similar to those found in other streams in the Chicago area during this period. These samples from other streams contain from 0.7 to 5.2 μμc of alpha activity per liter, 5.2 to 14.9 μμc of beta activity per liter, and 0.8 to 2.2 μμc of uranium per liter.

About one third of the Des Plaines River samples also were anlyzed for plutonium, thorium, strontium-90 and cesium-137, and no differences were found between locations. In all samples the strontium-90 and cesium-137 concentrations range from less than 0.5 to 1.1 μμc per liter, the thorium concentrations from less than 0.05 to 0.06 μμc/liter, and the plutonium concentrations were all less than 0.05 μμc/liter. These items are normal for the Chicago area. The results indicate that the radioactivity in Sawmill Creek had no detectable effect on the radioactivity in the Des Plaines River. This is presumably the result of dilution of Sawmill Creek water by the much larger volume of water in the Des Plaines River.

The gross activities found in the Illinois River during the second half of 1960 are given in the following table.

TABLE 8.—GROSS ALPHA AND BETA ACTIVITY IN THE ILLINOIS RIVER, SECOND HALF 1960

[Concentrations in μμc/liter]

Location	Date (1960)	Alpha	Beta
McKinley Woods State Park	July 28	4.6	14.2
McKinley Woods State Park	September 29	1.0	6.7
McKinley Woods State Park	November 16	2.5	6.5
Morris	November 16	2.3	5.9
Starved Rock State Park	November 16	1.7	7.2

General Conclusions

Except for a large reduction in the amount of fallout activity relative to the first half of 1959, the levels of environmental radioactivity during the second half of 1960 was generally the same as described in the first report of this series.

Oak Ridge National Laboratory

Union Carbide Nuclear Company
Oak Ridge, Tennessee

—Issued April 1961

Environmental levels of radioactivity at the Oak Ridge National Laboratory (ORNL) for 1959 and the first and second quarters of 1960 were reported in *Radiological Health Data,* Volume I, Number 9 and Volume II, Number 3. The following report presents a summary of the data for the fourth quarter of 1960.

Radioactive waste materials arising from the operations of Atomic Energy Installations at Oak Ridge are collected, treated, and disposed of according to their physical states.

Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filtration, scrubbing and/or precipitation. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to pits located in a Conasauga shale formation. Low level liquid wastes are discharged after preliminary treatment to the surface streams. Solid wastes are buried in a Conasauga shale formation. This shale has a marked ability to fix radioactive materials by an ion exchange mechanism.

Air Monitoring

Atmospheric contamination by long-lived fission products and fall-out occurring in the general environment of east Tennessee is monitored by two systems of monitoring stations. One system consists of seven stations which encircle the plant areas as shown in figure 1 and provides data for evaluating the impact of all Oak Ridge operations on the immediate environment.

FIGURE 1.—PERIMETER AIR MONITORING STATIONS, OAK RIDGE NATIONAL LABORATORY

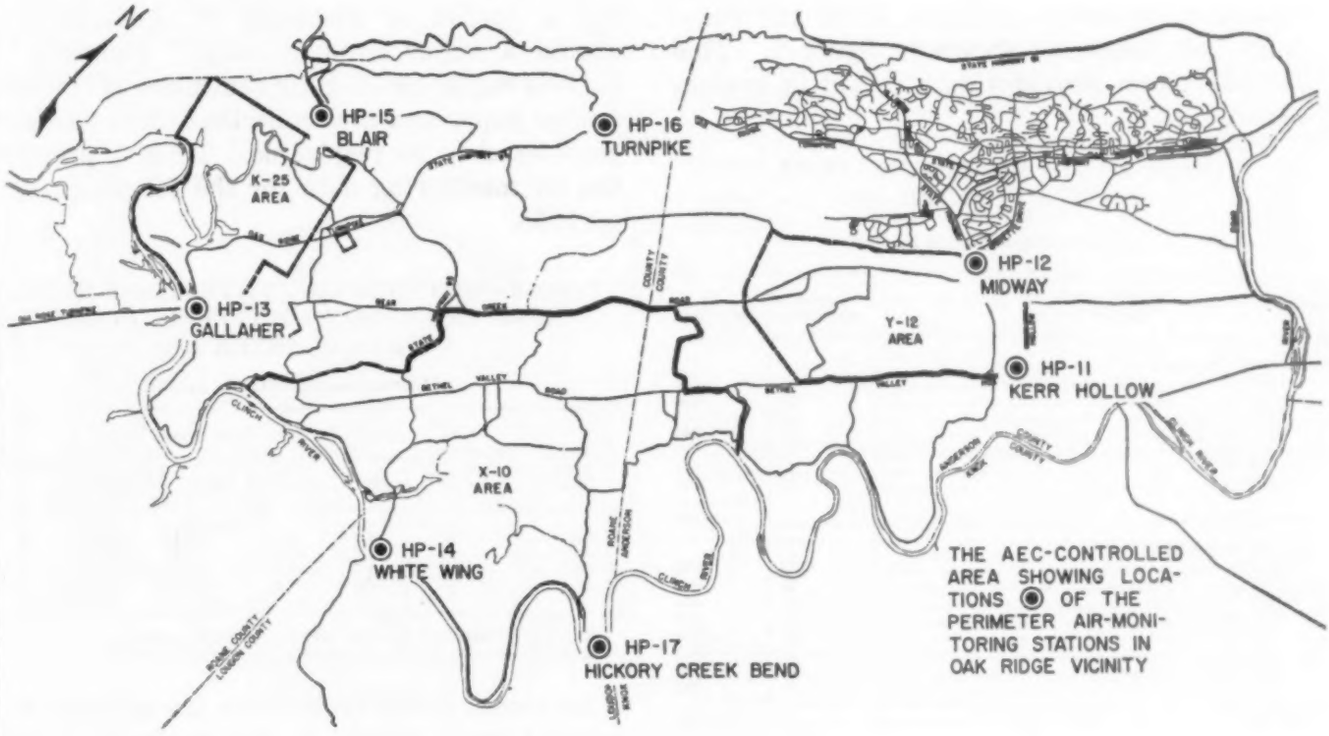
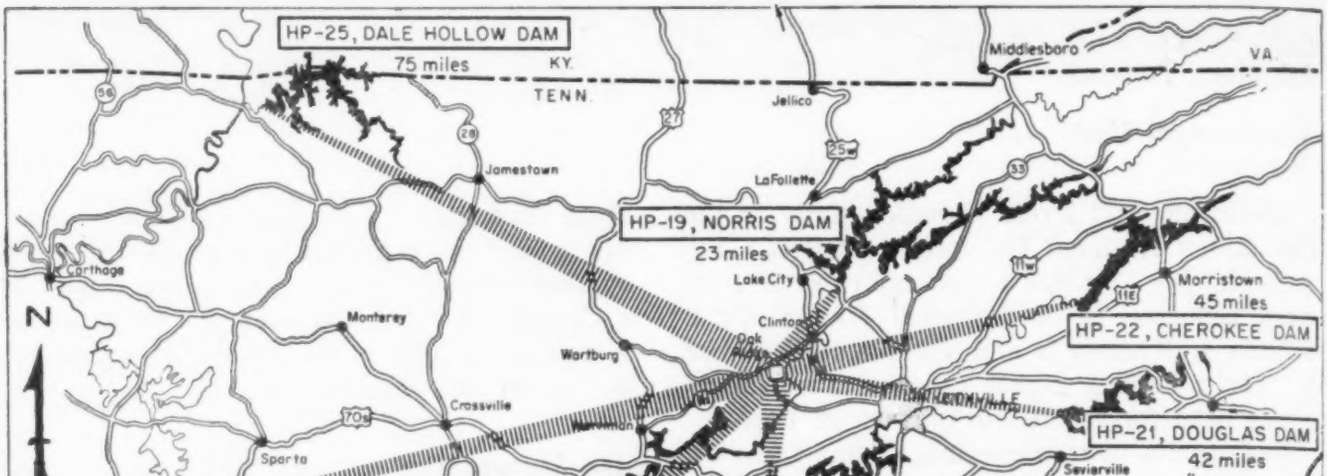


FIGURE 2.—REMOTE AIR MONITORING STATIONS, OAK RIDGE NATIONAL LABORATORY



A second system consists of eight stations located at distances of from 12 to 120 miles from Oak Ridge, as shown in figure 2. This second system provides data to aid in evaluating local conditions and to assist in determining a spread or dispersal of contamination should a major incident occur. Sampling is carried out by passing air continuously through a filter paper and thus collecting those particles considered to be respirable. Table 1 presents the air monitoring data for the fourth quarter of 1960.

TABLE 1.—AIR MONITORING DATA, FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c/m^3$]

Station number (see figs. 1 & 2)	Number of samples	Gross beta
Perimeter stations:		
HP-11	13	0.037
HP-12	13	.050
HP-13	13	.050
HP-14	13	.046
HP-15	13	.052
HP-16	13	.046
HP-17	13	.041
Average		0.046
Remote stations:		
HP-19	13	.080
HP-20	13	.049
HP-21	13	.046
HP-22	13	.041
HP-23	13	.052
HP-24	13	.049
HP-25	12	.038
HP-26	12	.034
Average		0.049

TABLE 2.—URANIUM CONCENTRATIONS IN AIR NEAR THE GASEOUS DIFFUSION PLANT, FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c/m^3$]

Distance from plant	Number of samples	Direction from plant				Average
		North	East	South	West	
[1] 2 miles	42	0.1	0.10	0.17	0.00	0.11
[2] 2 miles	16	27.0	31.2	3.9	18.0	18.8
[1] 5 miles	40	0.7	0.25	0.16	0.3	0.3
[2] 5 miles	16	16.9	9.3	4.9	1.1	1.1

[1] Reflects normal levels existing during most of the quarter.
[2] Reflects increased levels existing for a single sample period.

As shown in the table above the average airborne alpha activity in the environs of the

Gaseous Diffusion Plant was above the normally low level. A single period of increased activity which occurred early in November was coincident with a pilot stage run being made with highly enriched uranium materials and was largely responsible for this increase. Following completion of the short run, background values were again rapidly re-established; modification of the involved process is being studied. Of the 427 eight-hour continuous samples obtained in those plant operations areas where a stack or vent discharge of uranium materials is possible, less than one percent were above the maximum permissible concentration of occupational exposure (20 $\mu\mu c/m^3$) and the average was only a small fraction of this concentration.

Water Monitoring

Large-volume, low-level liquid wastes originating at Oak Ridge National Laboratory are discharged, after some preliminary treatment, into the Tennessee River system by way of White Oak Creek and the Clinch River. Liquid wastes originating at the Oak Ridge Gaseous Diffusion Plant (K-25 area) and the Y-12 plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that the resulting average concentrations in the Clinch River comply with the maximum permissible levels for populations in the neighborhood of a controlled area as recommended by the National Committee on Radiation Protection and Measurements (NCRP). The concentration of radioactivity leaving White Oak Creek is measured and concentrations values for the Clinch River are calculated on the basis of the dilution provided by the river.

Radioactive liquid wastes are sampled at a number of locations as shown in figures 4 and 5. Samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tennessee. Stream gauging operations are carried on continuously by the United States Geological Survey to obtain dilution factors for calculating the probable concentrations of wastes in the river. Water sampling stations on Poplar Creek upstream and downstream of the gaseous diffusion plant on Poplar Creek have been relocated upstream and downstream of the entry of Poplar Creek into Clinch River.

Samples are analyzed for the long-lived beta emitters, for uranium, and for the transuranic alpha emitters. Tables 3 and 4 present the results of these analyses for the fourth quarter of 1960.

Figure 3.—AIR SAMPLING STATIONS, K-25 AREA, OAK RIDGE NATIONAL LABORATORY

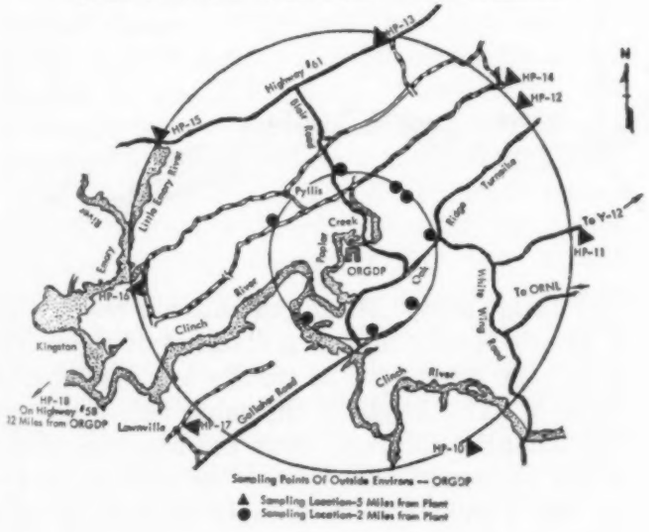


TABLE 3.—CONCENTRATIONS OF MAJOR RADIONUCLIDES IN THE CLINCH RIVER, FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c$/liter]

Location (see fig. 4)	Sr^{90}	Ce^{144}	Cs^{137}	$Ru^{106-106}$	Co^{60}	Gross beta
Upstream (mi. 37.5)	0.5	0.4	ND [2]	ND	ND	1.4
Point of entry [1] (mi. 20.8)	7.1	1.6	3.9	280	8.6	700
Downstream (mi. 4.5)	13.0	1.1	1.4	400	8.1	600

[1] Calculated values based on levels of waste released and the dilution afforded by the river.
[2] Not detectable by present instrumentation.

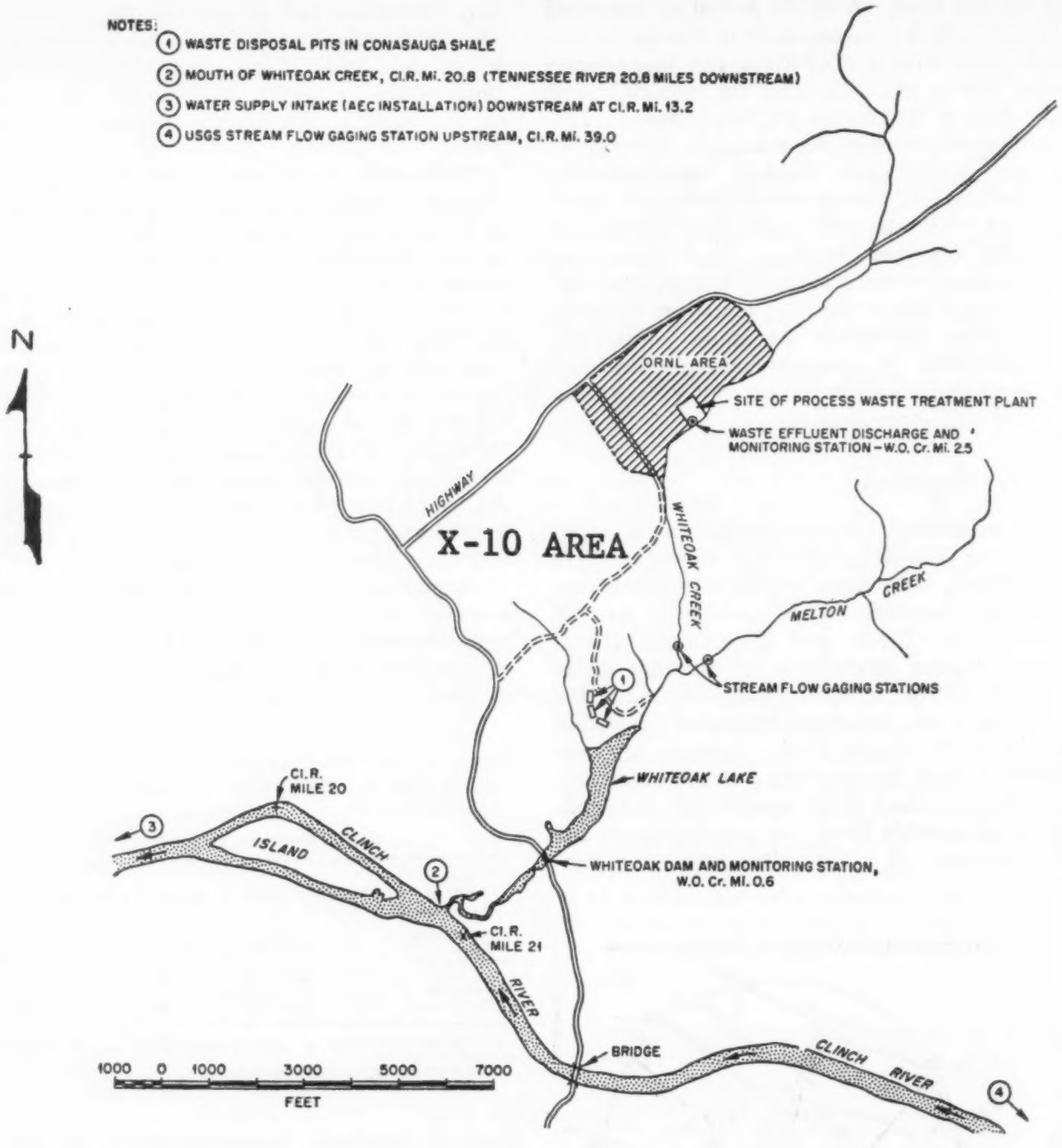
TABLE 4.—URANIUM CONCENTRATIONS IN THE CLINCH RIVER NEAR K-25 AREA, FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c$/liter]

Location (See fig. 5)	Number of samples [1]	Uranium concentration
Upstream from K-25	7	1.4
Downstream from K-25	7	2.7

[1] Normal sampling frequency: Continuous sampling composited over one week.

FIGURE 4.—LOCATION MAP, OAK RIDGE NATIONAL LABORATORY

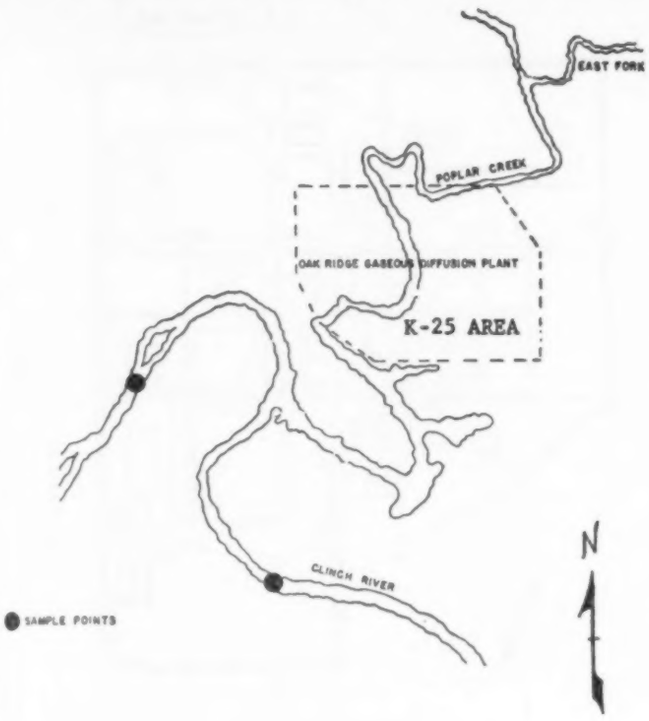

NOTES:
1 WASTE DISPOSAL PITS IN CONASAUGA SHALE
2 MOUTH OF WHITEOAK CREEK, Cl.R. Mi. 20.8 (TENNESSEE RIVER 20.8 MILES DOWNSTREAM)
3 WATER SUPPLY INTAKE (AEC INSTALLATION) DOWNSTREAM AT Cl.R. Mi. 13.2
4 USGS STREAM FLOW GAGING STATION UPSTREAM, Cl.R. Mi. 39.0
N
ORNL AREA
SITE OF PROCESS WASTE TREATMENT PLANT
WASTE EFFLUENT DISCHARGE AND MONITORING STATION – W.O. Cr. Mi. 2.5
HIGHWAY
X-10 AREA
WHITEOAK CREEK
MELTON
CREEK
STREAM FLOW GAGING STATIONS
WHITEOAK LAKE
Cl.R. MILE 20
ISLAND
CLINCH
WHITEOAK DAM AND MONITORING STATION, W.O. Cr. MI. 0.6
Cl.R. MILE 21
RIVER
BRIDGE
CLINCH RIVER
1000 0 1000 3000 5000 7000
FEET

The rise in concentrations of radioactivity in the Clinch River during this quarter reflects an increase in the quantity of radioactive materials discharged.

External Gamma

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge area. Measurements are taken with a Geiger-Muller tube at a distance of three feet above the ground. The results are tabulated in table 5. The levels in the table below are not significantly different from the average of the levels measured throughout the United States by the Public Health Service Radiation Surveillance Network.

FIGURE 5.—WATER SAMPLING STATIONS, K-25 AREA, OAK RIDGE NATIONAL LABORATORY



Conclusions

From the data presented, it seems evident that the Oak Ridge operations are contributing little to the air or ground contamination in the neighborhood of the area controlled by the Atomic Energy Commission. Some radioactivity has been contributed to the Clinch River by the release of radioactive liquid wastes, but concentrations of radioactivity in the river are well below the maximum permissible concentrations recommended by the NCRP for populations living in the vicinity of an atomic energy installation.

TABLE 5.—EXTERNAL GAMMA RADIATION LEVELS, FOURTH QUARTER 1960

[Average levels in mr/hr at 3 feet above ground]

Location (see fig. 1)	External gamma
Solway Gate	0.013
Y-12 East Portal	.013
Newcomb Road, Oak Ridge, Tenn.	.014
Gallaher Gate	.017
White Wing Gate	.016

Paducah Gaseous Diffusion Plant

Union Carbide Nuclear Company
Paducah, Kentucky

—Issued February 1961

Environmental levels of radioactivity at the Paducah Gaseous Diffusion Plant have been reported in *Radiological Health Data,* Volume I, Number 9, and Volume II, Number 3. The following report presents a summary of the data for the fourth quarter 1960.

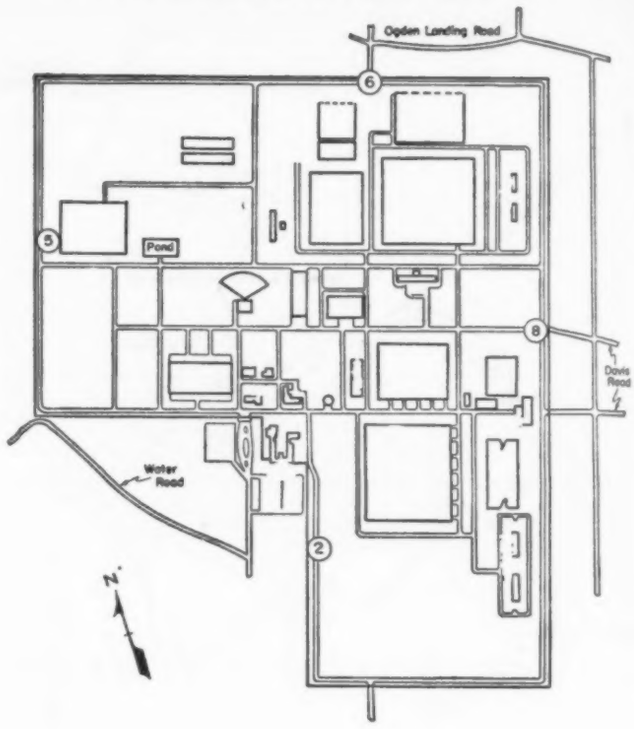
The Paducah Plant is a Government owned gaseous diffusion plant operated by Union Carbide Nuclear Company for the Atomic Energy Commission. The gaseous diffusion plant and the associated uranium hexafluoride manufacturing plant and uranium metal foundry process large quantities of relatively pure uranium compounds. The major sources of external penetrating radiation from such materials are the daughter-product isotopes of thorium and protoactinium formed by alpha decay and subsequent beta decay of the parent uranium. These isotopes are concentrated in the ash produced during the fluorination process. The element uranium can be a physiological hazard only if it enters the body. The chemical toxicity of the uranium materials processed at the Paducah Plant overshadows any radiation danger from this element, making it a physiological risk comparable to lead, mercury, or other well-known heavy metals.

Uranium is a rather expensive material, and thus represents a great incentive to recover as much as is economically feasible. To protect the population and to maintain a wholesome relationship with neighboring communities and individuals, the air is exhausted through

filters, and all effluent waters are discharged at extremely low concentrations of uranium.

Since no recovery process or filtering system is 100 percent efficient, an environmental monitoring program is used to evaluate the effectiveness of such measures. The Paducah Plant Environmental Monitoring Program consists of a continuing system for sampling air in four stations around the plant perimeter fence, and for sampling water at two locations in Big Bayou Creek, and four locations on the Ohio River as shown in figures 1 and 2. Tables 1 and 2 present the air and water monitoring data from the fourth quarter of 1960.

FIGURE 1.—AIR SAMPLING POSITIONS, PADUCAH GASEOUS DIFFUSION PLANT



IC2

TABLE 1.—GROSS AIR ACTIVITY—FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c/m^3$]

Location number (see fig. 1)	Number of samples	Uranium	Gross beta
2	12	<0.07	0.35
5	12	<0.07	<0.30
6	12	0.09	1.07
8	12	<0.07	0.44

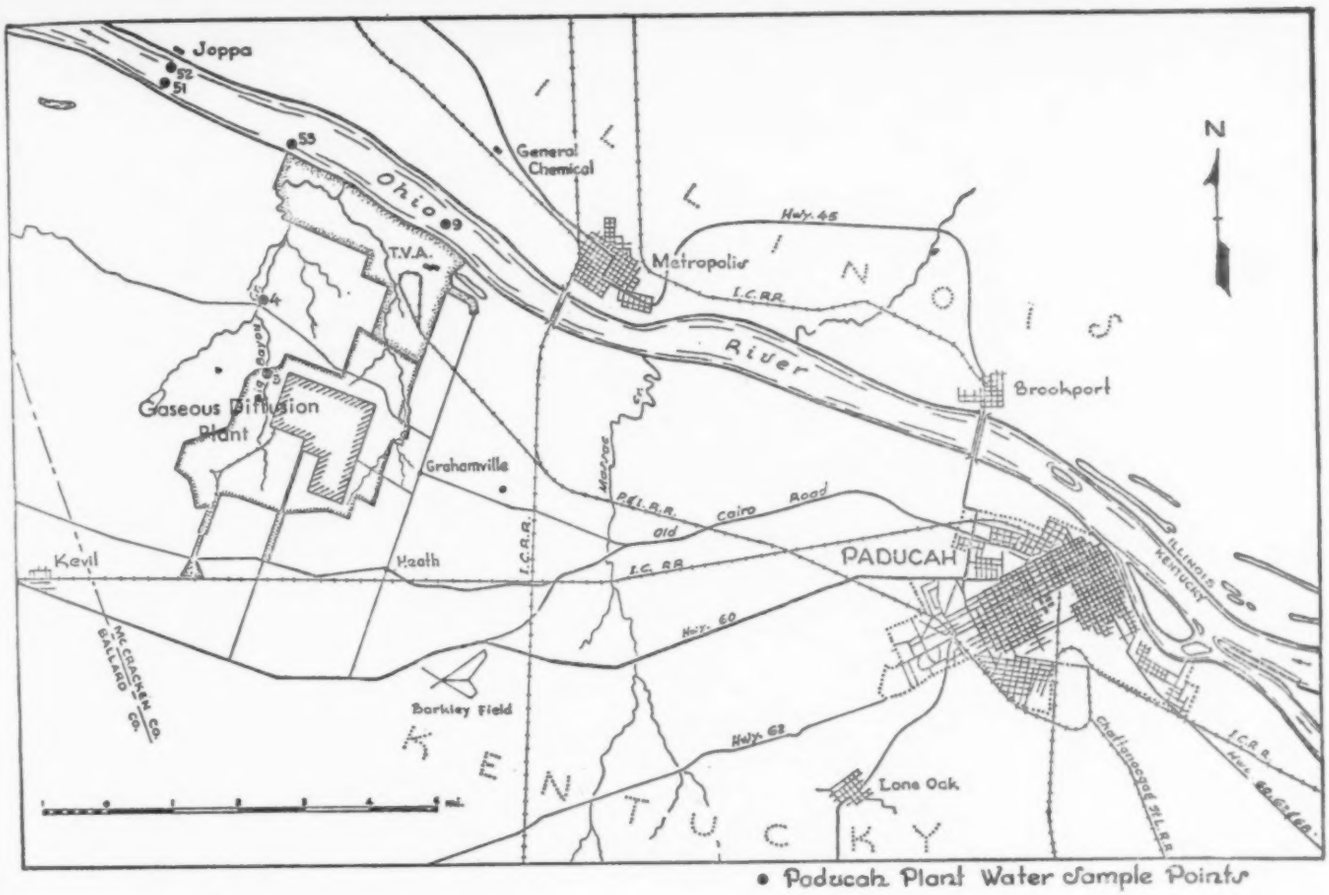
TABLE 2.—GROSS STREAM WATER ACTIVITY—FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c$/liter]

Location		Uranium		Gross beta	
Number (see fig. 2)	Description	Number of samples	Activity	Number of samples	Activity
3	Big Bayou leaving Government Land	16	[1] 1,590	13	200
4	Big Bayou at Ogden Bridge Road	6	200	3	600
9	Ohio River above Paducah Plant	6	<1	6	100
53	Ohio River below Paducah Plant	6	<1	6	200
51	Ohio River-south side at Joppa	6	<1	6	100
52	Ohio River-middle at Joppa	6	<1	6	100

[1] This group had a sample with a maximum value of 24,400 $\mu\mu c$/liter.
A micromicrocurie for recently extracted uranium, as defined in NBS Handbook No. 69, page 15, paragraph 3.2 is that amount of U^{238}, U^{235} and U^{230} which emits alpha particles at a rate 0.0849 disintegrations per second.

FIGURE 2.—WATER SAMPLING LOCATIONS, PADUCAH GASEOUS DIFFUSION PLANT



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